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ON
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AT
LAKE MANAWA, IOWA

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MISSOURI RIVER AT LAKE MANAWA, IOWA

COMPLETED
ORIGINAL

LETTER

FROM

THE SECRETARY OF THE ARMY

TRANSMITTING

A LETTER FROM THE CHIEF OF ENGINEERS, DEPARTMENT OF THE ARMY, DATED MAY 12, 1980, SUBMITTING A REPORT, TOGETHER WITH ACCOMPANYING PAPERS AND ILLUSTRATIONS, ON MISSOURI RIVER AT LAKE MANAWA, IOWA. THESE REPORTS ARE IN RESPONSE TO A RESOLUTION ADOPTED ON OCTOBER 30, 1975, BY THE COMMITTEE ON PUBLIC WORKS OF THE UNITED STATES SENATE

OCTOBER 10, 1980.—Referred to the Committee on Public Works

U.S. GOVERNMENT PRINTING OFFICE
WASHINGTON : 1980

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[Printed under authority of title 33, USC, section 701-1(a)]

LETTER OF TRANSMITTAL

DEPARTMENT OF THE ARMY
OFFICE OF THE ASSISTANT SECRETARY
WASHINGTON, D.C. 20310

REPLY TO
ATTENTION OF

2 JUL 1980

Honorable Jennings Randolph
Chairman, Committee on Environment
and Public Works
United States Senate
Washington, D. C. 20510

Dear Mr. Chairman:

I am transmitting herewith a report dated 12 May 1980 from the Chief of Engineers, Department of the Army, on Missouri River at Lake Manawa, Iowa, together with other pertinent reports. These reports are in response to a resolution adopted on 30 October 1975 by the Committee on Public Works of the United States Senate.

The views of the State of Iowa are set forth in the enclosed communications.

The Office of Management and Budget advises that there is no objection to the submission of the Chief of Engineers report to the Congress. A copy of the letter from the Office of Management and Budget is enclosed as part of the report.

Sincerely,

Michael Blumenfeld

Enclosure

Michael Blumenfeld
Assistant Secretary of the Army
(Civil Works)

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COMMENTS OF THE OFFICE OF MANAGEMENT AND BUDGET

EXECUTIVE OFFICE OF THE PRESIDENT
OFFICE OF MANAGEMENT AND BUDGET
WASHINGTON, D.C. 20503

June 16, 1980

Honorable Clifford Alexander
Secretary of the Army
Washington, D.C. 20310

Dear Mr. Secretary:

Assistant Secretary Michael Blumenfeld's letter of June 3, 1980, submitted the report of the Chief of Engineers on Missouri River at Lake Manawa, Iowa, for advice as to its relationship to the program of the President pursuant to Executive Order No. 12113, dated January 4, 1979.

The Chief of Engineers reports that U.S. Army Corps of Engineers participation in improvements for recreation and fish and wildlife opportunities at Lake Manawa, Iowa, is not advisable at this time, but that the appropriateness of dredging improvements be considered by other Federal agencies having such programs.

There would be no objection to the transmission of the proposed report to the Congress.

Sincerely,

Katherine Schirmer

Katherine P. Schirmer
Associate Director for
Natural Resources,
Energy and Science

COMMENTS OF THE STATE OF IOWA

Natural Resources Council

Wallace State Office Building
Des Moines Iowa 50319
(515) 281-5913

October 10, 1979

Lieutenant General J. W. Morris
Chief of Engineers
Department of the Army
Washington D.C. 20314

Dear General Morris:

Receipt of your report entitled Missouri River at Lake Manawa, Iowa is hereby acknowledged.

We have reviewed the report and find that alternative number 5 appears to be the most viable acceptable proposal. However, as stated in the report, it does not appear that the Corps of Engineers has any existing authority to proceed with any of the alternatives. Therefore, the State of Iowa will proceed with any restoration work that can be accomplished. We concur in the findings of the report.

Sincerely,

James R. Webb
Director

JRW/wg/iz

REPORT OF THE CHIEF OF ENGINEERS, DEPARTMENT OF THE ARMY

DEPARTMENT OF DEFENSE

DEPARTMENT OF THE ARMY
OFFICE OF THE CHIEF OF ENGINEERS
WASHINGTON, D.C. 20314

REPLY TO
ATTENTION OF:

DAEN-CWP-A 12 May 1980

SUBJECT: Missouri River at Lake Manawa, Iowa

THE SECRETARY OF THE ARMY

1. I submit for transmission to Congress my report on the Missouri River at Lake Manawa, Iowa. This report is accompanied by the reports of the Board of Engineers for Rivers and Harbors and the District and Division Engineers. These reports are in response to a resolution adopted on 30 October 1975 by the Committee on Public Works of the United States Senate. The Committee requested the Board to review the report on the Missouri River and other pertinent reports, with a view to determining whether any modifications of the recommendations contained therein are advisable with particular reference to improvements at Lake Manawa, Iowa.

2. The District and Division Engineers find that economic benefits for several dredging plans considered to improve Lake Manawa for recreation and fish and wildlife opportunities would be considerably less than the project costs. The plan considered to be most responsive to the study objectives and most compatible with the state master plan would, however, provide positive intangible and esthetic contributions to the environmental, regional, and social well-being accounts. Although there may be a Federal interest in improving lakes for recreation and fish and wildlife opportunities, the reporting officers find that the U. S. Army Corps of Engineers does not have Congressional authority for dredging Lake Manawa for these purposes only. However, the reporting officers state that dredging of Lake Manawa may be eligible for funding under programs of other Federal agencies. Therefore, they do not recommend implementation by the U. S. Army Corps of Engineers, but do recommend that other Federal agencies consider improving the lake by dredging.

3. The Board of Engineers for Rivers and Harbors, concurring in the findings of the reporting officers, recommends that U. S. Army Corps of Engineers participation in improvement for recreation and fish and wildlife opportunities at Lake Manawa, Iowa, is not advisable at this time, but that the appropriateness of dredging improvements be considered by other Federal agencies having such programs.

4. I concur in the recommendation of the Board.

JW Morris

J. W. MORRIS
Lieutenant General, USA
Chief of Engineers

REPORT OF THE BOARD OF ENGINEERS FOR RIVERS AND HARBORS

BERH-PLN (Jan 79) 2d Ind
SUBJECT: Missouri River at Lake Manawa, Iowa

Board of Engineers for Rivers and Harbors, Fort Belvoir, Virginia 22060 20 June 1979

TO: Chief of Engineers, Department of the Army

1. The Division Engineer issued a public notice on 6 April 1979 stating the findings and recommendations of the reporting officers and affording interested parties an opportunity to present additional information to the Board. No communications were received in response to the Division Engineer's public notice.

2. The reporting officers find that economic benefits for several dredging plans considered to improve Lake Manawa for recreation and fish and wildlife opportunities would be considerably less than the project costs. The plan considered to be most responsive to the study objectives and most compatible with the state master plan would, however, provide positive intangible and esthetic contributions to the environmental, regional, and social well-being accounts. The reporting officers further find that although Public Laws 88-578 and 92-500 indicate a Federal interest in improving lakes for recreation and fish and wildlife opportunities, the U.S. Army Corps of Engineers does not have Congressional authority to dredge Lake Manawa for these purposes only. However, they state that such dredging may be eligible for funding under programs of other Federal agencies. Accordingly, the reporting officers do not recommend implementation by the U.S. Army Corps of Engineers, but do recommend that other Federal agencies having such programs consider the appropriateness of improving the lake by dredging.

3. The Board of Engineers for Rivers and Harbors, concurring in the findings of the reporting officers, recommends that U.S. Army Corps of Engineers participation in improvements for recreation and fish and wildlife opportunities at Lake Manawa, Iowa, is not advisable at this time, but that the appropriateness of dredging improvements be considered by other Federal agencies having such programs.

FOR THE BOARD:

JAMES A. JOHNSON
Major General, USA
Chairman

REPORT OF THE DISTRICT ENGINEER

January 1979

REVIEW REPORT ON THE MISSOURI RIVER AT LAKE MANAWA, IOWA

The Study and Report

This report presents the findings of the survey study of the Missouri River at Lake Manawa, Iowa.

AUTHORITY

The Lake Manawa study was authorized by the following resolution dated 30 October 1975:

> "RESOLVED BY THE COMMITTEE ON PUBLIC WORKS OF THE UNITED STATES SENATE, that the Board of Engineers for Rivers and Harbors is hereby requested to review the report of the Chief of Engineers on the Missouri River, printed in House Document numbered 475, 78th Congress, and other pertinent reports, with a view to determining whether any modifications of the recommendations contained therein are advisable with particular reference to improvements at Lake Manawa, Iowa."

STUDY OBJECTIVES

The objectives of the study were to review and to refine earlier studies made by others in order to determine the advisability of dredging and of other improvements for recreation and fish and wildlife purposes at Lake Manawa.

The objectives were accomplished by:

Identifying the problems at Lake Manawa;

Developing alternatives for improvement of Lake Manawa for recreation and fish and wildlife purposes;

Evaluating and comparing the alternatives; and

Selecting the best plan.

STUDY AREA

Lake Manawa, shown on plate 1, is located in the Omaha, Nebraska-Council Bluffs, Iowa metropolitan area near the south edge of, and within, the city limits of Council Bluffs. The lake is an old oxbow of the Missouri River. It was formed when the river took a new channel during the flood of 1881. The lake has a surface area of 660 acres. Areas of the lake with depths of 5 feet or greater are considered suitable for boating; areas with depths of 2 feet or greater, which are free of emergent weeds, are considered suitable for fishing. The lake has 340 acres suitable for boating and 550 acres suitable for fishing.

Lake Manawa has been protected from floods on the Missouri River and its tributaries, Mosquito and Indian Creeks, since 1950 by the Corps of Engineers levees that are located on three sides of the lake. Although several residential neighborhoods have been developed around Lake Manawa, about 84 percent of the shoreline is publicly owned.

Lake Manawa is heavily used for recreation purposes. Visitation at Lake Manawa State Park was 690,000 in 1977. Lake Manawa State Park receives the highest visitation of all Iowa State Parks of its size; it provides facilities for camping, picnicking, boating, fishing, and swimming. Most of the existing facilities are overused. The Lake Manawa Master Plan was developed by Crose-Gardener Associates in 1975 for the Iowa Conservation Commission (ICC); it outlines suggested improvements of the facilities. The Master Plan will be completed over the next 10 years by the ICC as part of its capital improvements program.

Problem Identification

The major problems at Lake Manawa are shallow depths and a lake level that fluctuates if flows are not diverted into the lake, and dense vegetation caused by high nutrient levels. The shallow depths limit the area available for safe boating and also limit shoreline fishing. The shallow depths are attributable to sedimentation and the naturally fluctuating water surface elevation. Mosquito Creek provides a supplemental water supply for the lake; this water supply controls fluctuation of the water surface elevation but also introduces sedimentation to the lake.

Lake Manawa does not receive enough precipitation or runoff from its drainage area to maintain a constant water surface elevation suitable for recreation or fish and wildlife uses. Precipitation over the lake surface contributes about 1,650 acre-feet of water to the lake on an average annual basis. A small amount of inflow results from runoff from the residential areas, the park, and the golf course that surround the lake.

The average annual loss to evaporation is about 2,260 acre-feet. Lake Manawa is connected hydrologically to the alluvial aquifer which underlies the Missouri River flood plain. Evaporation and loss to the aquifer are the only source of outflow. When the lake surface elevation is maintained at 967.0 feet m.s.l., about 10 acre-feet of water per day is lost to the aquifer. Mosquito Creek provides the supplemental water supply to the lake to maintain a relatively constant water surface elevation. A 48-inch diameter reinforced concrete pipe diverts water from Mosquito Creek to Lake Manawa by gravity flow. The pipeline has a capacity of diverting up to 30 cubic feet per second (cfs) into Lake Manawa.

Considerable sedimentation has taken place in Lake Manawa since the lake was formed. The present rate of sedimentation, however, is low. Present lake depths are shown on plate 1 of the Technical Appendix. Density samples were taken in 1974 by the Corps of Engineers; these samples reveal bottom sediment accumulations up to 6 feet in depth. The rate of sediment accumulation during the period 1969 to 1974 was about 20 acre-feet per year. This is assumed to be the present rate of sedimentation into the lake. Lake Manawa has three sources of sediment inflow. Sediments from shoreline erosion, sediment inflows from Mosquito Creek, and sediment from aquatic deposition and other miscellaneous sources.

The dense stands of the American lotus prevent the use of about 15 percent of the lake for any purpose. The American lotus grows profusely in the three bays of the lake. It has grayish-green leaves which are up to 2 feet in diameter and stand several inches above the water. The American lotus grows in great profusion in areas with a depth of water of 3 feet or less. The plant is considered rare by geographic distribution in the western Iowa-eastern Nebraska area. Fish and wildlife benefits are provided by the American lotus during the spring and fall; however, during summer the dense growth of the plant prevents the use of areas infested with it.

Chemical water quality at Lake Manawa, although not a problem, is generally poor. Concentrations of total phosphorus in the lake are high; concentrations of inorganic nitrogen are generally low but occasionally are high. Dissolved oxygen (DO) appears to be well above minimum levels necessary for fishery maintenance. Fecal coliforms may be above the Iowa Water Quality Standards of 200 per 100 milliliters (ml) of water at times; however, these levels have not been measured during the time of the year when primary contact recreation occurs. Thus, no water quality problems exist, other than sedimentation, which would prevent use of the lake for recreation purposes.

Comparison Of Alternatives

The five alternatives formulated to improve the recreation and fish and wildlife opportunities at Lake Manawa share some common features, namely a dredge spoil detention area, diving area, and a fishery renovation program. The plan objectives for the alternatives are:

To increase the number and improve the quality of water based recreation opportunities at Lake Manawa; and

To increase the number and improve the quality of the fish and wildlife opportunities at the lake.

PLAN DESCRIPTION

Alternative 1 is shown on plate 3 of the technical appendix. This alternative would require dredging 400 acres. Depths after dredging would vary from 6 to 12 feet. The volume of spoil material created by the dredging would be about 2 million cubic yards. A 16-inch hydraulic cutterhead dredge, operating for about 23 months, could accomplish the dredging at an estimated cost of $4.9 million dollars. No dredging would be done within 150 feet of shore; this would prevent shoreline sloughing and erosion.

Alternative 2 is shown on plate 4 of the technical appendix. This alternative would require dredging 275 acres. Depths after dredging would vary from 8 to 13 feet. The volume of spoil material created by dredging would be about 2 million cubic yards. A 16-inch hydraulic dredge, operating for about 23 months, could accomplish the dredging at an estimated cost of $4.9 million. No shoreline protection work would be anticipated because no dredging would occur within 150 feet of the shoreline.

Alternative 3 is shown on plate 5 of the technical appendix. This alternative would require dredging 475 acres. Depths after dredging would vary from 5 to 13 feet. The volume of spoil material created by dredging would be about 2.9 million cubic yards. A 16-inch hydraulic cutterhead dredge, operating for about 27 months, could accomplish the dredging for an estimated cost of $6.7 million.

No shoreline protection work would be anticipated because no dredging would occur within 150 feet of the shoreline.

Alternative 4 is shown on plate 6 of the technical appendix. This alternative would require dredging 435 acres. Depths after dredging would vary from 6 to 13 feet. The volume of spoil material generated by dredging would be about 2.7 million cubic yards. A 16-inch hydraulic cutterhead dredge, operating for about 27 months, could accomplish the dredging at an estimated cost of $6.2 million. No shoreline protection work would be anticipated because no dredging would occur within 150 feet of the shore.

Alternative 5 is shown on plate 7 of the technical appendix. This alternative would require dredging 345 acres. The depth after dredging would be 6 feet except for 1.2 acres with a depth of 12 feet. The volume of spoil material created by dredging would be about 1.7 million cubic yards. Dredging would extend to the shoreline in some areas and would make extensive shoreline stabilization necessary. Underwater slopes from the shore would be about 1 to 3 and other underwater slopes would be about 1 to 12. A 16-inch hydraulic cutterhead dredge, operating for about 23 months, could accomplish the dredging at an estimated cost of $4.6 million.

DREDGE SPOIL DISPOSAL AREA

The 216-acre dredge spoil disposal site south of the lake would not involve the destruction of prime or unique farmland or designated wetland areas. The site which is currently used for agricultural purposes is a portion of the 330-acre tract acquired by the state of Iowa with Land and Water Conservation Fund Act funds for expansion of Lake Manawa State Park. The area will be converted from agricultural to recreational land use. Dredge material would be transported from the lake by pipeline and deposited in a primary detention basin where the sand and heavier sediment would settle out of the water. Two primary detention basins would be provided to allow some flexibility in the disposal area. Because large volumes of material would be deposited, it could become necessary to discontinue disposal into one basin and use earth moving equipment to redistribute the sediments contained in that basin. Two secondary detention basins would also be provided. Flow between the primary and secondary detention basins would be controlled by overflow weirs. Minimum detention time in both detention basins would be 7 days.

Some of the fine sediment suspended during dredging would not settle out by gravity in the dredge spoil area; therefore, chemical coagulants would be mixed into the water flowing from the primary to the secondary detention basins. The coagulant would cause the remaining fine sediments to settle out. The water would then be returned to the lake.

FISHERY RENOVATION

Although dredging would have some beneficial impacts on fish and wildlife opportunities at Lake Manawa, none of the dredging alternatives would significantly improve these opportunities. Wildlife opportunities are limited, and would remain limited, because of the urbanized setting of the lake. It was determined by the ICC that improvements in the fishery at the lake could best be attained by initiating a fishery renovation program. Each alternative would include a fishery renovation program which would remove the non-game fish species from Lake Manawa and replace them with game fish. All fish species except channel catfish and bullhead would be removed; restocking species would consist of channel catfish, largemouth bass, crappie, bluegill, and tiger muskie. An additional impact of fishery renovation, however, would be a reduction in turbidity because of the removal of the carp population. This reduction in turbidity would result in rapid growth of algae and, possibly, macrophytes in the lake. It has been suggested by the ICC that control of the growth of macrophytes could be accomplished by the release of white amur into the lake; this course of action has been followed by the ICC in similar situations with acceptable results.

DIVING AREA

Each alternative would provide a diving area adjacent to the swimming beach proposed in the Master Plan. The diving area would have a depth of 12 feet. Alternative 1 would provide 18 acres of diving area and Alternatives 2 through 5 would provide 1.2 acres of diving area.

PLAN EVALUATION

The five alternatives were compared with respect to:

- Contribution to plan objectives;
- Relationship to national economic development, environmental quality, social well being, and regional development; and
- Relationship to other associated evaluation criteria, such as compatibility with the Master Plan and acceptability to local interests.

CONTRIBUTION TO PLAN OBJECTIVES

Alternative 1 would provide 132 additional acres suitable for boating recreation; it would also provide a greater degree of safety to boaters because of the deeper water. The only improvements for fish and wildlife would be the creation, through dredging, of a greater volume of water to support a fishery and the provision of a variable depth lake bottom. Alternative 1 would not reduce the number of water surface acres available for growth of the American lotus.

Alternative 2 would provide 50 additional acres suitable for boating. A greater degree of safety would be provided to boaters in the deeper waters and a larger lake volume would be available to support a fishery. A lake bottom with variable depths for fishery enhancement would also be created. Alternative 2 would not cause a reduction in the number of water surface acres available for growth of the American lotus. Implementation of Alternative 2 would remove much of the fine, highly organic sediments present in the lake bottom.

Alternative 3 would provide an additional 209 acres for boating and an additional 77 acres for fishing. The area available for growth of the American lotus would be reduced by 14 percent. Alternative 3 would also remove a significant quantity of fine, highly organic sediments from the bottom of the lake.

Alternative 4 would increase the number of acres available for boating by 122 and would increase the number of acres available for fishing by 37. A larger volume of water to support a fishery and a variable depth lake bottom would also be created. Alternative 4 would reduce the area available for the growth of the American lotus by 7 percent.

Alternative 5 would provide an additional 271 acres for boating and an additional 72 acres for fishing. Alternative 5 would also make 12,300 feet of shoreline accessible for fishing. The riprapped shoreline would also provide fish spawning habitat. Alternative 5 would reduce the area available for growth of the American lotus by 13 percent.

SELECTING A PLAN

Appropriate criteria for selecting a plan for Lake Manawa include contributions to the planning objectives, relationship to the four accounts, and associated evaluation criteria. A summary comparison of the five alternatives is shown in table 1.

Alternative 5 is the selected plan. It was selected because it would provide for the greatest increase in the number of acres deep enough for recreation uses at the least cost. Alternative 5 would provide environmental enhancement which the other alternatives lack and would create less temporary environmental destruction than all alternatives except Alternative 2. Alternative 5 is more compatible with the Lake Manawa State Park Master Plan than any of the other alternatives and it has public acceptability.

Full evaluation of NED benefits was not included as part of the NED account due to lack of data. Based on criteria used for evaluation of recreation and fish and wildlife opportunities at Corps projects, it appears that the quantitative benefits would be considerably less than the project costs. The plan would, however, provide positive intangible and esthetic contributions to the consideration of environmental, regional, and social well being benefits.

Table 1
Summary of Alternative Plans

	Alternative 1	2	3	4	5
A. Plan Description					
Acres with depths of 5' or greater available after dredging which are not now available	132	50	209	122	271
Acres with weed-free depths of 2' or greater available after dredging which are not now available	0	0	77	37	72
Acres suitable for diving	18	1.2	1.2	1.2	1.2
B. Significant Impacts Specified in Section 122 of PL 91-611	Included in "Relationship to Four Accounts"				
C. Plan Evaluation					
1. Contributions to Planning Objectives					
a. Improved Recreation Objectives					
Increased acres available for Recreation	132	50	209	122	271
New Diving Acres	18	1.2	1.2	1.2	1.2
Shoreline Access for Fishing(feet)	0	0	0	0	12,300
b. Improved Fish and Wildlife Opportunities					
Increased Volume of Water for fishery Support (yd ^{3})	1,997,000	1,966,000	2,887,000	2,671,000	1,690,000
Improved Shoreline Habitat (ft)	0	0	0	0	12,300
Fishery Renovation	Yes	Yes	Yes	Yes	Yes

	Alternative 1	2	3	4	5
2. Relationship to Four Accounts					
a. National Economic Development (NED)					
Total Annual Cost at 6.875 Percent Interest Rate Over 50 Years	357,300	353,400	482,900	452,600	335,300
b. Environmental Quality (EQ)					
Feet of improved shore fish habitat	0	0	0	0	12,300
Destruction of benthic organisms and aquatic vegetation	400	275	475	435	345
c. Social Well Being (SWB)					
Acres with depth of 5' greater available after dredging which are not presently available	132	50	209	122	271
Acres with weed-free depth of 2' or greater available after dredging which are not presently available	0	0	77	37	72
Diving areas created (acres)	18	1.2	1.2	1.2	1.2
Shoreline Fishing Access Created (ft)	0	0	0	0	12,300
d. Regional Development Land Enhancement (lots)	50	50	50	50	50
3. Plan Response to Associate Criteria					
Acceptability	Yes	Yes	Yes	Yes	Yes

The Selected Plan

PLAN DESCRIPTION

Pertinent data and the cost estimate for Alternative 5 are shown in table 2 and table 3. The plan would involve dredging about 344 acres of the lake to a depth of 6 feet. The area of the lake with depths of 5 feet or greater would be increased from 340 acres to 611 acres; the area of the lake with emergent weed-free depths of 2 feet or greater would be increased from 550 acres to 622 acres; and 1.2 acres would be suitable for diving. Fishing access along the shore of the lake would be provided by dredging to the shoreline on a 1 to 3 slope. The shoreline fishing area would have a length of 12,300 feet and would be located near parking lots and areas designated for fishing access in the Master Plan. The shoreline fishing area would be riprapped to prevent erosion of the steep slope and warning signs would be posted at 150-foot intervals. The riprapped shoreline would provide spawning habitat for the fishery.

No dredging would be conducted near the nature areas, wading beaches, or swimming beaches; this would insure compatibility between the Master Plan and the dredging plan.

The dredge spoil disposal area would be located on a 216 acre site south of the lake. The site would be divided into four basins; two primary detention basins and two secondary detention basins. Dredge spoil would be discharged from the dredge pipeline into one of the primary detention basins where sand and heavier sediments would settle out. The water and remaining sediments

Table 2
Pertinent Data
Selected Plan

Volume of Excavation, cubic yards	1,690,000
Area of Excavation, acres	345
Construction Period, months	23
Dredging Plant:	
Dredge, hydraulic cutterhead	16-inch
Pipeline Diameter	16-inch
Flow, GPM	11,460
Exit Velocity in Detention Basin, feet per second	22
Dredge Spoil Disposal Areas:	
Area, acres	216
Levee height, feet (average)	10
Minimum detention time, days	7

Table 3
Cost Estimate
Selected Plan

Item	Quanity	Unit	Unit Cost	Total Cost
Mobilization and Demobilization			L.S.	$ 200,000
Dredging	1,690,000	c.y.	$ 1.50	2,535,000
Levees	165,300	c.y.	0.95	157,000
Water Drainage				
Drainage Channels - Excavation	4,500	c.y.	0.90	4,050
Drainage Channels - Backfill	4,500	c.y.	1.90	8,550
Road Crossing Culverts	2	each	5,800	11,600
Wiers	6	each	14,300	85,800
Chemical Coagulation			L.S.	115,000
Seeding	13	acres	615	8,000
Riprap				
Rock	16,700	ton	10	167,000
Filter Cloth	34,000	sq.yd.	11	84,000
Fishery Renovation			L.S.	126,000
Construction Contingencies			L.S.	518,000
Subtotal				$3,970,000
Engineering and Design				318,000
Supervision and Administration				278,000
				$4,566,000
Annual Operation and Maintenance Cost				$ 9,700

would flow over a weir from the primary detention basin to a secondary detention basin. Chemical coagulant would be injected into the water as it flows over the weir. Cost estimates are based on the use of conventional coagulants. Additional research, however, has indicated that use of polyelectrolytes as coagulants may be more economical. The addition of a chemical coagulant would cause the fine sediments suspended in the water to settle out. The clear water would be returned to the lake by an earthen channel; therefore, under Public Law 92-500 a Section 404 permit would be required. The dredge spoil disposal areas would be capable of handling a dredge spoil volume of 11,460 gallons per minute (GPM) over a period of 8 months.

The fishery renovation program would be an integral part of the selected plan. Replacement of rough fish by game fish would result in an improvement in the fishery at the lake. It would also result in a decrease in turbidity which could result in accelerated growth of macrophytes or, possibly, algae.

SUMMARY OF SECTION 404(B) REPORT

A Section 404(b) report is an evaluation of the effects caused by the selected plan on certain water quality parameters. These parameters are established by the Environmental Protection Agency and the Corps of Engineers.

The construction activities associated with this project would cause temporary increases in turbidity. These increases would be largely localized and might cause some reduction of light transmittance and have some negative effect on the esthetics of the lake. Sedimentation patterns would change immediately adjacent to the dredging activity; however, these effects should be minor. The discharge from the dredge spoil areas would not affect any public water supplies, concentrated shellfish areas, significant fish spawning and nursery areas, wildlife or aquatic sanctuaries, recreation areas, or threatened or endangered species. The food chain production and some existing benthos communities would be adversely affected by the selected plan while the general aquatic habitat of the lake would be beneficially affected. The riprapped areas and the 216 acre disposal site would reduce existing vegetation and might adversely affect the nesting and rearing sites and food supply of selected terrestrial species. All disposal material would be placed in the most practical manner to accomplish the potential dredging project with the least amount of material, expense, and environmental damage.

Plan Implementation

The Corps of Engineers has no legislative basis to recommend the authorization of dredging at Lake Manawa for improvement of recreation and fish and wildlife opportunities. However, the potential plan may be eligible for funding under the programs of other agencies. A Federal interest in the improvement of lakes used for recreation and fish and wildlife purposes has been exhibited by legislation contained in Public Law 88-578 and Public Law 92-500.

The Environmental Protection Agency has the authority to fund lake restoration projects under Section 314 and 104(h) of Public Law 92-500 (Clean Lakes Program). The Federal share of funding under the Clean Lakes Program is limited to 50 percent of the total project cost. The remaining 50 percent of the cost must be paid by non-Federal interests; however, revenue sharing funds and Department of Housing and Urban Development block grants can be used for the 50 percent cost-share by non-Federal interests.

The Heritage Conservation and Recreation Service (formerly the Bureau of Outdoor Recreation) also makes funds available to states under the provisions of the Land and Water Conservation Fund Act of 1965 on a 50-50 cost sharing basis with the state.

Funds for implementation of dredging could be obtained from this program. The priority on the use of these funds within the State of Iowa is determined by the Iowa Conservation Commission.

State and local agencies have indicated that they lack the capability to fund the total project.

Conclusions

Alternative 5 has been selected by the local interests and the State as the plan for improvement of recreation and fish and wildlife opportunities at Lake Manawa. It appears that the quantitative economic benefits for dredging to improve Lake Manawa would be considerably less than the costs of dredging. Dredging, however, is the only viable means of creating additional acres suitable for recreation uses at Lake Manawa.

Although there may be a Federal interest in dredging of lakes to improve recreation and fish and wildlife opportunities, the Corps of Engineers has no Congressional authority for dredging of Lake Manawa. However, the potential dredging may be eligible for funding under programs of other Federal agencies.

Recommendations

I recommend no Congressional action. The Corps of Engineers has no legislative basis to recommend authority to dredge Lake Manawa to improve recreation and fish and wildlife opportunities. However, I recommend that the appropriateness of improving the lake by dredging be considered by other Federal agencies having such programs including the Environmental Protection Agency, the Heritage Conservation and Recreation Service, and Department of Housing and Urban Development.

JAMES W. RAY
Colonel, Corps of Engineers
District Engineer

[First endorsement]

MRDPD-PF(Jan 1979)
SUBJECT: Review Report on the Missouri River at Lake Manawa, Iowa

DA, Missouri River Division, Corps of Engineers, PO Box 103,
Downtown Station, Omaha, Nebraska 68101 6 April 1979

TO: Board of Engineers for Rivers and Harbors, Kingman Building,
Fort Belvoir, VA 22060

I concur in the recommendation of the District Engineer.

C. A. SELLECK, JR.
Colonel, Corps of Engineers
Division Engineer

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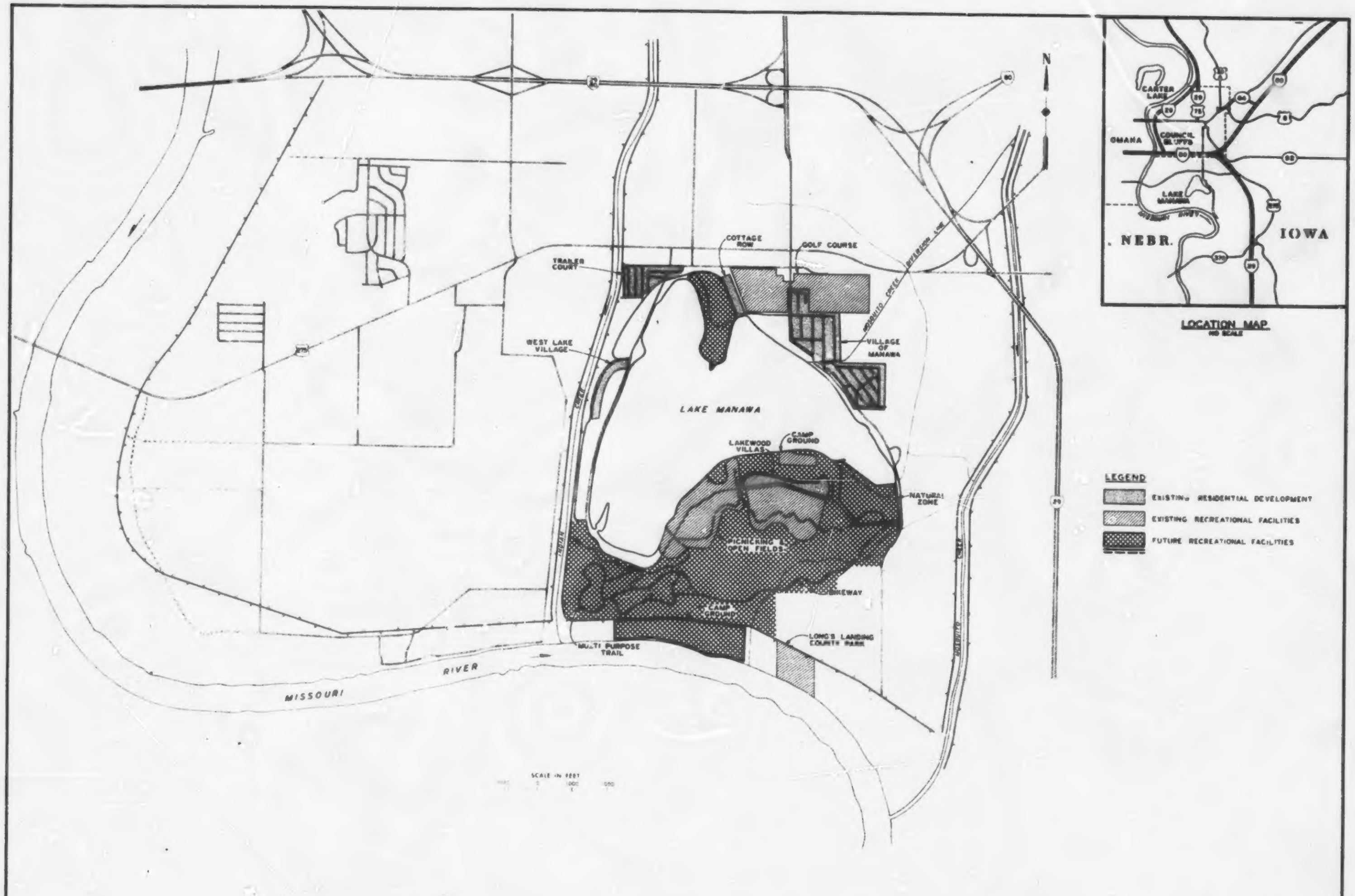

LEGEND

- ▨ EXISTING RESIDENTIAL DEVELOPMENT
- ▨ EXISTING RECREATIONAL FACILITIES
- ▩ FUTURE RECREATIONAL FACILITIES

THIS DRAWING HAS BEEN REDUCED TO THREE-EIGHTHS THE ORIGINAL SCALE

LAKE MANAWA, IOWA
STUDY AREA

U.S. ARMY ENGINEER DISTRICT, OMAHA
CORPS OF ENGINEERS OMAHA, NEBRASKA
FEB 1978

PLATE 1

APPENDIX A

DESCRIPTION OF STUDY AREA

Geography and Geology

The geographic boundaries of the study area are shown on plate 1 of the Summary Report. Lake Manawa lies within the boundaries of the Omaha, Nebraska-Council Bluffs, Iowa Standard Metropolitan Statistical Area (SMSA). Lake Manawa lies in the flood plain of the Missouri River. The dominant features of the flood plain are the loess bluffs to the northeast of the lake and the Missouri River which flows south of the lake. The lake is bounded on the east and west by Mosquito and Indian Creeks, respectively. The geology of the Missouri River valley is typical of an alluvial flood plain with layers of sand, gravel, and silt. Thick and extensive deposits of sandstone and limestone underlie the Missouri River at depths of 1,000 feet or more.

Climate

Weather in the Lake Manawa area is typical of the interior of a large landmass in the temperate zone. Rapid weather changes are caused by invasions of large masses of warm, moist air from the Gulf of Mexico, hot, dry air from the Southwest, cool, moist air from the Pacific Ocean, and cold, dry air from Canada.

The average annual precipitation is about 30 inches. About 70 percent of the average annual precipitation normally falls during the crop growing season from April through September. Localized intense thunderstorms are common in the area. Droughts have severely affected the area at various times. The periods of 1887 to 1896, 1924 to 1927, 1934 to 1941, and 1952 to 1956 were particularly severe. Average annual evaporation is about 41 inches. The mean maximum temperature in January is 33 degrees and in July it is 90 degrees. The mean minimum temperature in January is 13 degrees and in July it is 66 degrees. Prevailing winds are from the southeast during May through October and from the northwest during November through April.

Natural Resources

WATER RESOURCES

Both surface water and ground water resources are present in the study area. Indian Creek and Mosquito Creek are tributary streams to the Missouri River. Both Indian and Mosquito Creek are intermittent streams, drying up during periods of extreme drought. Although water quality data are limited, the available data indicates that Mosquito Creek has high quality water during non-runoff periods. Significant increases in pollutant values occur as Mosquito Creek flows through Council Bluffs and passes by Lake Manawa. Indian Creek is grossly polluted in the Lake Manawa area.

The Missouri River is the major surface source of water supply available in the study area. The minimum flow in the Missouri River is greater than 5,000 cubic feet per second (cfs). The Missouri River has good quality water with the exception of high fecal coliform concentrations; this indicates that other parameters, such as viruses, may be above acceptable limits.

Both shallow and deep ground water resources are present in the study area. The shallow aquifer is composed of Quaternary period sand and gravel deposits which may be confined or unconfined. Wells greater than 500 feet deep in this area should yield more than 300 gallons per minute (GPM). At depths greater than 1,000 feet large quantities of ground water are stored in thick, extensive deposits of sandstone and limestone. Dissolved solids in shallow ground water deposits range from 250 parts per million (ppm) to

500 ppm; chlorides are less than 150 ppm; and sulfates are less than 250 ppm. Water quality in the deep aquifer is more variable. Dissolved solids range from less than 250 ppm to more than 4,000 ppm, chlorides range from less than 150 ppm to more than 600 ppm; sulfates range from less than 250 ppm to more than 1,000 ppm.

SOILS

The soils in the Lake Manawa area are flood plain soils weathered from alluvial parent material. The soils contain little organic matter and are not generally suitable for establishment of hardwood or coniferous timber. Crop production is viable with the use of artificial fertilizers. The land in the Mosquito Creek basin is used mainly for agricultural purposes. During runoff periods significant quantities of sediment and nutrients are transported to Mosquito Creek.

MINERAL RESOURCES

Sand and gravel are the major minerals present in the study area. No commercial exploitation of these resources is presently occurring.

Environmental Setting

FLORA

Native vegetation on the Lake Manawa area is a combination of decidious flood plain forest, mixed grasses, marshland and introduced species. Sparse tree cover and brush distinguish much of the shoreline. Undeveloped land surrounding the lake is heavily covered with prairie grass. The lake contains various species of rooted aquatics and algae, however, the most notable species present is Nelumbo lutea, the American lotus which is considered rare in this geographic area. It grows in three bays of the lake, an area of roughly 110 acres. The American lotus has grayish-green leaves up to 2 feet in diameter and grows profusely in depths of 3 feet or less.

Typical tree species found in the Lake Manawa area are oak (Quercus), hickory (Carya spp.), green ash (Fraxinus pennsylvania), black walnut (Juglans nigra), elms (Ulmus spp.) boxelder (Acer Negundo), mulberry (Morus nubra), and silver maple (Acer saccharinum). Tree species found close to the water are plains cottonwood (Populus deltoides sargentii) and various willows (Salix spp.).

Woody shrubs and vines common in the area include rough-leaved dogwood (Cornus drummondii), wild plum (Prunus americana), chokecherry (Prunus virginiana), elderberry (Sambucus canadensis), gooseberry (Ribes spp.), and wild grape (Vitis riparia and V. vulpina).

Common herbaceous plants and grasses found in the area include stinging nettle (Uritca dioica), small and giant ragweed (Ambrosia artemisifolia and A. trifida), smooth brome (Bromus inermis), foxtails (Setaria spp.), and reed canary grass (Phalaris arundinacea). These plants are normally found as understory and ground cover associated with the hardwood forest community described above.

Aquatic vegetation in the Lake Manawa area is extensive in and around the lake's perimeter. Plants found in the area are cattails (Typha latifolia), arrowhead (Sagittaria spp.), bulrushes (Scirpus spp.), which grow at the water's edge, and duckweed (Lemna minor), which grows on the water surface. Several species of bluegreen and green algae as well as numerous species of diatoms are present in Lake Manawa. The potential for abundant algal growth exists at the lake.

TERRESTRIAL WILDLIFE RESOURCES

All of Lake Manawa State Park is officially considered a wildlife refuge. Several species classified as game animals may inhabit the area where suitable habitat is present. These are the cottontail rabbit, fox squirrel, bobwhite quail and ring-necked pheasant. Several non-game species are also present including the raccoon, mink, weasel, beaver, muskrat, oppossum, and striped skunk. Rodents common to the area include moles, shrews, ground squirrels, field mice and rats. Whitetail deer are native to the area, howeber, because of the residential development around Lake Manawa, they have not been sighted at the lake for a number of years. Other larger mammals such as the red fox and coyote are probably not very abundant in the area due to the lack of suitable or adequate habitat. The small mammals are relatively abundant due to the shortage of predators and the abundance of food, in the form of agricultural crops produced in the area.

Birdlife in the area is abundant with respect to the number of species seen. However, as is the case with other animal species in the lake area, the absolute number of birds is a function of habitat availability. As many as 100 or more different species of birds may be observed at Lake Manawa in any given year. However, individuals of each species seen, and numbers of resting pairs per unit area during the nesting season, are relatively small due to the habitat conditions previously described. The lake is located along one of the major migratory waterfowl flyways, it is also officially designated as an open water refuge. Many species of waterfowl such as blue-winged and green-winged teal, mallard, gadwall, wood duck, white front and snow geese use the lake as a stopping place during migration. Observations indicate that the main concentrations of waterfowl are in the Nelumbo lutea beds and surrounding emergents during the spring and fall.

Aquatic animals that may be found in the area are some species of turtles, crayfish, tiger salamander, leopard frog and bull frog.

FISHERY RESOURCES

Fish species present in the lake include bluegill, crappie, largemouth bass, carp. bullhead, yellow bass, fresh water drum, shad, and channel catfish. The most sought after fish in Lake Manawa is the catfish. Lake Manawa contains an extremely high population of shad. Its numbers are increasing, probably because of the lack of predator fish found in the lake.

BENTHIC RESOURCES

The benthic community of Lake Manawa was examined from 13 April 1978 to 11 July 1978. During this time period no significant organisms were encountered and quantitative samples of the benthic species were numerically low.

Benthic species found in Lake Manawa include pond snails, fingernail clams, bloodworms, leeches, tubifex, and a few insects. The tubifex and the bloodworm comprised the largest volume and percentaged sampled. These particular species usually dominate eutrophic lakes such as Lake Manawa.

The only sample which displayed high benthic concentration was the Mosquito Creek site sampled on 13 June 1978. The remainder of the samples were numerically and volumetrically low. The numerical values generated were insufficient to establish any viable trend. Usually the volume of benthic organisms will increase as water temperature increases, however, the data of Lake Manawa is not conclusive of this pattern.

The samples from sites 1 and 2 were very small, grayish in color and somewhat polluted in later samples as the temperature increased. The 3rd site contained a granular mixture of mud and sand, while the 4th (floater) site in both locations consisted of primarily organic matter such as leaves, weeds, and wood fragments.

Most of the organisms found on the lake bottom are not unique to this zone. They represent for the most part, a few species of the larger littoral bottom fauna that can tolerate severe stagnation. Even these, if subject to continuous stagnation, will be eliminated wholly or in part. Bottom fauna is restocked from egg stages carried over during periods of stress or by downward migration from the littoral bottom during seasonal turnover.

As the water becomes more shallow, the benthos changes. The bottom materials—stones, rubble, gravel, clay—are modified by the action of water, by plant growth, by drift materials, and by recent organic deposits. Increased oxygen, light, and food results in a richness of species and an abundance not found on the lake bottom. Here on the bottom of the littoral zone live, in addition to the tube worms, the midges, and numerous other plant and detritus feeders.

HISTORICAL AND ARCHEOLOGICAL RESOURCES

Iowa state and local archeological and historical agencies have surveyed the Lake Manawa area. No significant findings have been reported from either survey. If historical objects as defined in Iowa Code 205A.4, are found during the dredging process (archeological and paleontological objects of antiquity), all dredging should be halted or bypass the finds until the State Archeologist has been notified and can take appropriate action.

Population

The Omaha-Council Bluffs SMSA had a population of 525,905 in 1975. The Office of Business and Economic Research Service Series E (OBERS Series E) population projections for 1980 and 1990 are 577,300 and 638,500 respectively.

Transportation

The lake is located within 2 miles of the intersection of Interstates 80 and 29. Access to the lake is provided by a paved four-lane road. A paved two-lane road encircles the lake and provides access to residential areas and the State Park facilities.

Recreation

The counties which surround Lake Manawa (Pottawattamie and Mills Counties in Iowa and Douglas and Sarpy Counties in Nebraska) provide 90 percent of the visitation at the lake. This visitation is very high for such a small park and reflects the scarcity of public water-oriented resources and facilities in the four county area. Recreation demand at Lake Manawa will continue to be high because of the great disparity between supply and demand for water based recreation. In 1974, the demand was 7.2 million recreation days. A total of 2 million recreation days are available at parks in the counties. Competition from future recreation sites will be minimal. Table A-1 shows the recreation demand for the area through 1990.

The lake is not zoned for boating, therefore, power boats and sailing vessels compete for the same area. The overuse of the lake is evident when the present boat to water acre ratio is compared to the State of Iowa's standards. In Iowa's State Comprehensive Outdoor Recreation Plan (SCORP) the standards are 1 boat to 5 acres for boating and 1 boat to 10 acres for water skiing. The boat to water acre ratio at Lake Manawa is 1 boat to 2.4 acres. This crowded situation coupled with the shallow lake water depths and sandbars has caused groundings and damages to boats.

Table A-1
Recreation Demands
For Douglas and Sarpy Counties in Nebraska and Pottawattamie County in Iowa

Activity	Recreation demand in water surface acres	
	1980	1990
Lake Fishing	47,000	48,600
Power Boating	36,000	56,300
Water Skiing	15,800	27,700
Sailing	4,900	6,200
Beach Swimming	16	20
Total of Water Surface Acres	103,700	138,800
Existing Acres in Water	2,600	2,700
Need	101,100	136,100

APPENDIX B

PROBLEM IDENTIFICATION

Prior Studies

Prior studies that have been conducted of Lake Manawa are as follows:

Title	Date	Remarks
Lake Manawa Preliminary Engineering Report, Iowa State Conservation Commission	1952	Preliminary study of Mosquito Creek water to Lake Manawa
Water for Manawa, Iowa State Conservation Commission	1953	Feasibility study of diverting Mosquito Creek water to Lake Manawa
A Preliminary Study of the Dredging Programs, Benefits, Costs and Effects for Eight Iowa Lakes; Economics Research Associates	1975	Dredging feasibility study for eight Iowa lakes, including Lake Manawa
Lake Manawa State Park Master Plan, Crose-Gardner Associates	1975	Master Plan for development of recreation facilities for Lake Manawa State Park
Water Management, Water Quality and Alluvial Morphology of Selected Iowa Oxbow Lakes: Iowa State University	1977	Water quality data on Lake Manawa

Problems and Needs

SEDIMENT DENSITY MEASUREMENTS

Sediment density measurements were conducted during 1974 by the Corps of Engineers. Samples were taken using a radioactive sediment density probe. The results of the sampling are shown in table B-1. Locations of the sampling sites are shown on plate 1.

SHORELINE CHANGES AND SEDIMENTATION

SHORELINE CHANGES

Changes in the Lake Manawa shoreline have been well documented by three detailed surveys of the lake. Two of these were made in 1930 and 1969 by the Iowa Conservation Commission. The last was made in 1974 by the Corps of Engineers. Changes are evident in three areas of the lake; the peninsula at the north end of the lake and the shoreline along the southeast and southwest corners of the lake. Only the peninsula at the north end has shown appreciable erosion. Planimetered aerial changes along the peninsula show erosion rates for the 1969-1974 period averaging 1.8 acres per year. During a field survey of the erosion sites in 1977, it was observed that although water depths and the underwater slopes are shallow and relatively flat, the

Table B-1
Sediment Density Observations
Lake Manawa, Iowa
Sampled on 10 September 1974

	Elevation m.s.l.				Densities Lbs/Ft^3		Total
Location*	Water Surface	Top of Deposit	Probe Centroid	Maximum Penetration**	Wet	Dry	Depth of Sediment
1	967.3	962.8	962.2	961.3	95.3	52.84***	-
2	967.3	963.2	961.8		96.6	55.31	5.5
			960.7		114.7	84.03	
			959.1		115.3	84.93	
			958.6	957.7	113.8	82.68	
3	967.3	959.1	957.2		82.4	32.12	6.0
			955.9		91.4	46.57	
			954.5		113.6	82.23	
			954.0	953.1	115.1	84.70	
4	967.3	959.8	959.1		94.5	51.52	1.8
			958.9	958.0	98.5	57.96	
5.	967.3	958.5	956.9		79.7	27.78	7.8
			955.9		80.1	28.43	
			954.9		80.0	28.27	
			953.9		81.5	30.67	
			952.9		108.2	73.55	
			951.9		115.6	85.38	
			951.6	950.7	113.7	82.04	
6	967.3	962.3	960.9		98.5	57.91	5.2
			959.9		90.7	45.39	
			958.9		100.7	61.51	
			958.0	957.1	97.2	55.76	
7	967.3	958.4	956.9		79.1	26.85	10.60
			955.9		79.7	27.78	
			954.9		80.3	28.72	
			953.9		80.1	23.43	
			952.9		82.3	31.96	
			951.9		90.0	44.32	
			950.6		94.6	51.71	
			949.0		90.1	44.49	
			948.7	947.8	89.2	43.42	
8	967.3	961.0	960.6	959.7	92.0	47.54***	
9	967.3	962.3	960.9		88.9	42.46	5.3
			959.9		100.5	61.13	
			958.9		100.8	61.71	
			958.5		101.4	62.53	
			957.9	957.0	106.2	70.34	

NOTE: Densities determined through use of radioactive sediment density probe.

* Locations are shown on plate 1.

** Probe tip is 0.9 feet below probe centroid.

*** Densities may be heavier than shown due to inadequate penetration of probe into sediment deposit.

shoreline sediments are fine-grained and easily erodible. Propwash and wave action from waterskiing is more than enough to induce erosion and cause it to continue over the foreseeable future until stabilized controls are implemented. Stabilization of the peninsula could be attained by spreading a layer of coarse gravel or riprap along the shoreline.

Measured changes in the shoreline along the two southern corners of the lake are the result of slightly higher lake levels occurring on each succeeding survey date, rather than bank erosion. Although some of the increased levels can be accounted for by sediment depletion, the major share of the increase is thought to be the result of greater volumes of water in the lake at the time of the surveys.

SEDIMENTATION HISTORY

Historically, sediment deposition in Lake Manawa has come from seven sources. These are: (1) Missouri River flood inflows; (2) Missouri River water diversion; (3) lake shoreline erosion; (4) aquatic plant deposition; (5) Mosquito Creek water diversion; (6) local storm runoff; and (7) miscellaneous sources such as dust fall, wind-blown soils from perimeter roads and local farmlands, and tree leaves.

A review of the history of these sources must include reference to the extensive dredging conducted at the lake from 1935 to 1939. New volumes for sediment storage were created during that interval. Consequently, deposition being measured in the lake to date must be referenced back to 1939 as the initial year of deposit.

Sediments from Flood Inflow. Prior to completion of the Omaha-Council Bluffs levee in 1950, the shoreline at Lake Manawa occasionally underwent substantial change because of the periodic inflow of sediment-laden flood waters from the Missouri River. With the construction of the levee in 1950, the periodic inflows of river water were halted as a contributing source of sediments. However, in the period from 1939 to 1950 hydrological records show that at least one major flood event occurred with overflow sufficient to have deposited a sizable volume of sediment into the lake. This flood occurred in April 1943 and had a peak discharge of 200,000 cfs. River stages reached a maximum elevation of 980.69 feet m.s.l. at a nearby USGS gage location. Estimates are not available, unfortunately, as to the volume of sediments brought into the lake, but the volume could well have been the major source of sediments deposited in the lake since 1939.

Sediments from Missouri River Water Diversion. In an effort to restabilize lake levels in 1953 and 1954, water was pumped into Lake Manawa from the Missouri River at a reported rate of 13,000,000 gallons per day. Again the rate and volume of the sediments contributed were not monitored. However, evidence of a point bar extending into the lake away from the pipe inlet provides reasonably good evidence that some sediments were being contributed.

Sediments from Shoreline Erosion. Except for erosion along the peninsula, very little of the lake shoreline has contributed an appreciable amount of sediment since the dredging in 1939. If differences in the water level at the time of the lake surveys (1930, 1969, and 1974) are ignored, our studies show that the erosion rate along the peninsula shoreline was about 0.8 acre per year from 1939 to 1969, and 1.8 acre per year from 1969 to 1974. The smaller rate for the 1939 to 1969 period reflects a rate averaged over 30 years of record. While this rate is probably more realistic of a long-term average erosion rate than the shorter period average for 1969 to 1974, its use as such may be questionable due to inaccuracies in the 1939 survey, and any stabilizing tendencies the shoreline might currently have.

Sediments from Mosquito Creek. Similar to the diversion of water from the Missouri during 1953 and 1954, water from Mosquito Creek has been diverted into Lake Manawa since 1956 to stabilize the lake levels. The maximum reported diversion rate is 25 cubic feet per second, with the daily rate dependent on the availability of supply from the upland drainages. Water diverted into the lake, however, is assumed to be free of sediments because of the temporary impounding effect of the diversion weir in the creek. Evidence that some sediments are entering the lake via this source, though, is documented on sounding charts showing the presence of a sediment deposition flume extending several hundred feet outward from the pipe inlet.

Sediment from Aquatic Deposition and Other Miscellaneous Sources. Of the available sources of sediment inflow, sediment accumulation from aquatic deposition and miscellaneous sources are the most difficult to document, both quantitatively and historically. Measurements of the organic fraction of the bed sediments indicate that aquatic plants and algae constitute the largest annual volume of deposition occurring within the lake. But no reliable means are currently available to assess the yield from this source, nor provide an "a priori" estimate of the annual variability. Of the total sediment deposits from all sources measured between 1969 and 1974, it is estimated that aquatic deposition and sediments from miscellaneous sources may account for as much as 44 percent of the total annual lake depletion. The remaining loss in the lake storage volume is assumed to be derived from bank erosion, and the redistribution of sediments within the lake. The 44 percent estimate above is based on the percentages of organic matter and fine sediments measured in lake bed sediment samples collected in 1977. This data is summarized in table B-2. Sampling locations are shown on plate 1.

Table B-2

SUMMARY OF LAKE SEDIMENT SAMPLES

		DRY UNIT WEIGHT			VOLUMETRIC PERCENTAGE	
SAMPLE LOCATION	ORGANIC FRACTION (%) 1/	TOTAL SAMPLE (PCF) 2/	ORGANIC FRACTION (PCF)	SAND FRACTION (PCF)	ORGANIC FRACTION (%)	SAND FRACTION (%)
1	3.56	52.84	1.88	50.96	63.70	36.30
2	3.56	55.31	1.97	53.34	66.68	33.32
3	8.59	32.12	2.76	29.36	36.70	63.30
4	7.72	51.52	3.98	47.54	59.43	40.57
5	7.72	27.78	2.14	25.64	32.05	67.95
7	10.63	26.85	2.85	24.00	30.00	70.00
8	7.92	47.54	3.77	43.77	54.72	45.28
9	8.40	42.46	3.57	38.89	48.61	51.39
AVERAGE	6.45	37.38	2.55	34.83	43.54	56.46

1/ Organic fraction is the percent of organic material from "Loss On Ignition" tests run by MRD Lab on bed surface samples obtained in 1977.

2/ Dry unit weight from density probe measurements made in 1974.

SEDIMENTATION RATE COMPUTATION

The rate of sediment accumulation was determined by comparing the lake sounding contour map made by the Iowa Conservation Commission (ICC) in 1969 with the lake sounding contour map made by the Corps in 1974. The rate of sediment accumulation during the period from 1969 to 1974 was determined to be about 20 acre-feet per year. The assessment of sedimentation for that period revealed that 166 acres of the lake bed surface area had degraded and 410 acres had aggraded. Based on the residual difference between the 1969 and 1974 bed maps, the volumes of aggradation and degradation were found to be 178 and 70 acre-feet, respectively; this amounts to a difference of 108 acre-feet between the aggraded and degraded volumes which cannot be accounted for through redistribution. This difference of 108 acre-feet, or 60 percent of the total deposit, came from sources such as dust fallout, rainfall runoff, shoreline erosion, inflow from Mosquito Creek, and organic deposition.

The average depth of new deposit, assumed to be uniformly distributed within the confines of the 410 acres of aggraded bed surface area, was estimated to be 0.4 feet. Of this, the average depth of deposit of new sediments was determined to be 0.3 feet.

Lake bed samples indicate that approximately 44 percent of the sediment deposited between 1969 and 1974 is organic and will decompose or compact with time. On this basis an average annual depletion rate of 20 acre-feet per year was selected.

A hyposometric analysis of the sedimentation rate at Lake Manawa, conducted by the Iowa State University (ISU), indicated an average annual depletion of about 30 acre-feet per year.

The degree of correlation between the two rates of sedimentation was considered to be adequate in view of the short period of observation and the contour interval used in mapping the lake bottoms. The present rate of sedimentation was assumed to be 20 acre-feet per year because measures have been taken by the ICC since 1974 to further regulate the quantity of sediment inflow to the lake. During runoff periods in the spring and following severe thunderstorms in the summer and fall, the Mosquito Creek Diversion is shut off; this prevents the entrance of large quantities of suspended sediment into the lake. A visual inspection of supplemental flow into the lake is made several times a day; when turbidity in the water is visible, diversion is discontinued.

HYDROLOGIC INTERRELATIONSHIP BETWEEN THE LAKE AND THE AQUIFER

One impact of maintaining a constant water surface elevation of 967.0 feet m.s.l. is the loss of water from the lake to the aquifer. The water table in the vicinity of Lake Manawa lies at an elevation of 965.0 feet m.s.l. to 963.0 feet m.s.l. The rate of water loss from the lake to the aquifer was determined by comparing hydrologic conditions to lake surface elevations during a period of time when diversion to the lake was not occurring. Loss rates were computed for three distinct time periods. A loss rate of about 10 acre-feet per year with a water surface elevation of 967.0 feet m.s.l. was computed. Maintenance of the water surface at a lower elevation would result in less loss to the aquifer; however, this action would result in the need for deeper dredging to maintain a sufficient depth for recreation use. Dredging of the lake would result in an increased rate of infiltration to the aquifer for a period of time. Redistribution of fine sediments should reseal the bottom of the lake after a period of time. The rate of loss which would occur after dredging is not known.

VEGETATION

Dense stands of Nelumbo lutea, the American lotus, prevent utilization of about 15 percent of the lake for any purpose during the summer months. The three shallow bays of the lake are completely clogged by this plant. Fish and wildlife benefits are provided by this plant during the spring and fall of the year, however, during the summer the dense growth of this vegetation prevents use of the area. The plant is considered to be esthetically pleasing during blooming periods, however, Nelumbo lutea is rare by geographic distribution in the Lake Manawa area. The American lotus in Lake Manawa is an outlier population at the northwestern edge of the plant's range. Lake Manawa is an ideal habitat for this species; it thrives in nutrient rich waters at depths of 3 feet or less. Research on the origin of this species is currently underway at the University of Nebraska at Lincoln.

WATER QUALITY

There are no water quality problems at Lake Manawa which prevent it from being used as a recreation area. No consistent sampling program is conducted at the lake by either the Iowa Department of Environmental Quality (DEQ) or the Iowa Department of Health (IDH). Iowa State University at Ames, Iowa sampled the water quality of Lake Manawa in the summer of 1977. Table B-3 presents the results of their study. The Corps of Engineers conducted a water quality survey for Lake Manawa in 1978. The results of their study are presented on table B-4. In general, the Corps of Engineers data agrees with Iowa State University. Sampling sites for both surveys are shown on plate 2.

Dissolved oxygen (DO) appears to be well above minimum levels necessary for fishery maintenance throughout the water column. Occasionally lower DO values were observed near the lake bottom due to oxygen utilization by the bottom sediments.

Total phosphorous levels are high in Lake Manawa, ranging from 0.04 - 0.20 mg/l for the period 13 April through 17 July. Even the minimum observed phosphorous levels could support intense algal blooms provided other parameter levels were adequate.

Inorganic nitrogen levels are usually low ranging from 0.01 - 0.45 mg/l for the period 13 April through 17 July. Inorganic nitrogen would be periodically limiting to algal growth, however, short periods of high nitrogen availability do occur occasionally.

Algal abundance in Lake Manawa was moderate at all sampling stations except for the period 13 through 26 June. This algal bloom period indicates that the potential for severe algal blooms is present. The persistent turbidity results in light limitation which is most likely the limiting factor suppressing algal growth. The algal data also indicate the bluegreen algae average over 60 percent of the total algal population. *Merismopedia* sp., a small bluegreen alga, accounted for a numerically large percentage of the total algal population. On a volume basis, this alga would account for a much smaller percentage. Yellowgreen algae also represented a large segment of the algal population averaging nearly 30 percent of the total population during the test period. This would be expected since this group is normally dominant in the early part of the year while the water is still relatively cold. However, because the yellowgreen algal population was still prominent in the June and July samplings, this segment of the algal population may be significant throughout the year.

Table B-3
WATER QUALITY SAMPLING DATA AT LAKE MANAWA (ISU)

DEPTH M	TEMP C	SUSP. SOLIDS MG/L	PH	SP. COND	D.O. MG/L	PHTH ALK MG/L AS CACO3	TOTAL ALK MG/L AS CACO3	TURB JTU	CHLOROPHYLL A MG/CUBIC METER	TOTAL PHOS MG/L
SITE A. SAMPLED ON 06/16/77 SECCHI DEPTH = 0.4 M										
0.	23.3	26.13	8.3	475.	7.4	****	198.	12.5	38.10	0.125
1.	23.9	22.13	8.4	465.	7.4	****	198.	10.0	38.68	0.134
2.	23.3	27.13	8.3	480.	7.5	****	198.	9.0	38.26	0.125
BOTTOM	23.3	******	***	****	****	****	****	*****	******	*****
SITE B. SAMPLED ON 06/16/77 SECCHI DEPTH = 0.3 M										
0.	23.3	31.93	8.3	460.	7.8	****	200.	6.5	36.69	0.146
1.	23.3	40.53	8.3	455.	8.0	****	200.	14.0	38.88	0.167
2.	23.3	45.73	8.3	460.	7.2	****	208.	15.0	44.20	0.158
BOTTOM	23.3	******	***	****	****	****	****	*****	******	*****
SITE C. SAMPLED ON 06/16/77 SECCHI DEPTH = 0.6 M										
0.	23.9	13.73	8.4	450.	9.4	****	200.	7.0	17.75	0.108
1.	24.0	21.73	8.4	450.	10.4	****	210.	8.0	80.82	0.023
BOTTOM	24.4	******	***	****	****	****	****	******	*******	*****
SITE A. SAMPLED ON 07/05/77 SECCHI DEPTH = 0.2 M										
0.	25.6	30.13	8.4	460.	7.6	****	210.	15.0	43.58	0.120
1.	25.0	32.13	8.4	460.	7.7	****	200.	9.5	41.82	0.136
BOTTOM	25.0	******	***	****	****	****	****	*****	******	*****

SOURCE: Water Management, Water Quality and Alluvial Morphology of Selected Iowa Oxbow Lakes, Iowa State University, 1977.

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Table B-3 (Con't)

DEPTH M	TEMP C	SUSP. SOLIDS MG/L	PH	SP. COND	D.O. MG/L	PHTH ALK MG/L AS CACO3	TOTAL ALK MG/L AS CACO3	TURB JTU	CHLOROPHYLL A MG/CUBIC METER	TOTAL PHOS MG/L
SITE B. SAMPLED ON 07/05/77 SECCHI DEPTH = 0.1 M										
0.	25.0	33.73	8.4	460.	8.1	****	210.	10.0	45.76	0.136
1.	25.0	35.33	8.4	460.	8.1	****	200.	12.5	35.68	0.120
BOTTOM	24.4	******	***	****	****	****	****	*****	******	*****
SITE C. SAMPLED ON 07/05/77 SECCHI DEPTH = 0.1 M										
0.	23.3	26.93	7.8	465.	6.8	****	197.	8.0	66.57	0.119
1.	22.2	26.13	7.8	465.	5.8	****	197.	14.0	58.04	0.132
BOTTOM	22.2	******	***	****	****	****	****	*****	******	*****
SITE A. SAMPLED ON 07/20/77 SECCHI DEPTH = 0.3 M										
0.	26.7	50.53	8.5	410.	11.3	4.0	160.	26.0	115.17	0.190
1.	26.1	48.53	8.5	400.	11.7	2.5	162.	26.0	109.83	0.202
BOTTOM	25.0	******	***	****	****	****	****	*****	******	*****
SITE B. SAMPLED ON 07/20/77 SECCHI DEPTH = 0.4 M										
0.	27.2	42.53	8.6	400.	11.5	7.0	163.	22.0	100.38	0.160
1.	26.1	34.93	8.6	410.	9.2	5.0	171.	32.0	91.00	0.177
BOTTOM	24.4	******	***	****	****	****	****	*****	******	*****

Table B-3 (Con't)

DEPTH M	TEMP C	SUSP. SOLIDS MG/L	PH	SP. COND	D.O. MG/L	PHTH ALK MG/L AS CACO3	TOTAL ALK MG/L AS CACO3	TURB JTU	CHLOROPHYLL A MG/CUBIC METER	TOTAL PHOS MG/L
SITE C. SAMPLED ON 07/20/77 SECCHI DEPTH = 0.5 M										
0.	27.8	29.33	8.5	400.	10.6	6.0	167.	17.0	71.32	0.112
BOTTOM	26.1	26.13	8.5	410.	10.5	4.5	169.	14.0	79.24	0.125
SITE A. SAMPLED ON 08/01/77 SECCHI DEPTH = 0.1 M										
0.	23.9	35.33	8.6	400.	9.0	7.0	156.	15.0	104.80	0.139
1.	23.9	31.53	8.6	400.	9.0	6.0	156.	17.5	105.66	0.182
2.	23.9	******	***	****	****	****	****	*****	******	*****
BOTTOM	23.9	******	***	****	****	****	****	*****	******	*****
SITE B. SAMPLED ON 08/01/77 SECCHI DEPTH = 0.1 M										
0.	23.3	46.53	8.6	390.	8.5	5.0	156.	22.0	106.48	0.153
1.	23.3	41.53	8.6	400.	8.2	3.0	155.	22.0	96.71	0.166
BOTTOM	23.3	******	***	****	****	****	****	*****	******	*****
SITE C. SAMPLED ON 08/01/77 SECCHI DEPTH = 0.1 M										
0.	23.3	34.13	8.0	410.	6.6	****	162.	17.0	82.67	0.140
BOTTOM	23.3	******	***	****	****	****	****	*****	******	*****
SITE A. SAMPLED ON 08/09/77 SECCHI DEPTH = 0.3 M										
0.	23.3	24.53	8.4	390.	6.7	****	149.	15.0	107.83	0.163

Table B-3. (Con't)

DEPTH M	TEMP C	SUSP. SOLIDS MG/L	PH	SP. COND	D.O. MG/L	PHTH ALK MG/L AS CACO3	TOTAL ALK MG/L AS CACO3	TURB JTU	CHLOROPHYLL A MG/CUBIC METER	TOTAL PHOS MG/L
SITE A. SAMPLED ON 08/09/77 SECCHI DEPTH = 0.3 M										
1.	23.9	28.13	8.3	390.	6.8	****	151.	10.0	106.80	0.161
2.	23.9	33.93	8.2	390.	6.4	****	152.	17.0	99.98	0.181
BOTTOM	24.4	******	***	****	****	****	****	*****	******	*****
SITE B. SAMPLED ON 08/09/77 SECCHI DEPTH = 0.2 M										
0.	24.4	42.93	8.4	390.	7.4	****	149.	15.0	102.66	0.179
1.	24.4	45.73	8.4	390.	7.2	****	151.	13.0	100.25	0.179
BOTTOM	23.9	******	***	****	****	****	****	*****	******	*****
SITE C. SAMPLED ON 08/09/77 SECCHI DEPTH = 0.4 M										
0.	23.3	21.33	8.1	420.	6.5	****	134.	8.0	73.66	0.128
BOTTOM	23.3	******	***	****	****	****	****	*****	******	*****
SITE A. SAMPLED ON 08/22/77 SECCHI DEPTH = 0.2 M										
0.	22.2	30.93	8.4	370.	8.8	****	155.	16.0	117.50	0.171
1.	22.2	31.93	8.4	375.	7.7	****	154.	18.0	114.57	0.171
2.	22.2	36.93	8.2	375.	8.2	****	153.	15.0	104.48	0.149
BOTTOM	21.7	******	***	****	****	****	****	*****	******	*****

Table B-3 (Con't)

DEPTH M	TEMP C	SUSP. SOLIDS MG/L	PH	SP. COND	D.O. MG/L	PHTH ALK MG/L AS CACO3	TOTAL ALK MG/L CACO3	TURB JTU	CHLOROPHYLL A MG/CUBIC METER	TOTAL PHOS MG/L
SITE B. SAMPLED ON 08/22/77 SECCHI DEPTH = 0.1 M										
0.	21.7	42.93	8.3	370.	7.6	****	150.	18.0	120.84	0.172
1.	21.7	40.93	8.3	370.	7.8	****	152.	17.0	111.52	0.173
BOTTOM	21.7	******	***	****	****	****	****	*****	******	*****
SITE C. SAMPLED ON 08/22/77 SECCHI DEPTH = 0.3 M										
0.	22.2	31.13	8.0	370.	6.8	****	148.	11.0	80.67	0.132
BOTTOM	21.7	******	***	****	****	****	****	*****	******	*****

TABLE D-4
WATER QUALITY SAMPLING DATA AT LAKE [illegible] -
(CORPS OF ENGINEERS) - SITE 1

Sampling Date Depth (Meters)	18 April	27 April	12 May
Air Temp. (°C)	19.5	17.0	15.0
Secchi Depth (Meters)	0.30	0.38	0.94
Bottom Depth (Meters)	2.60	2.65	2.60
BOD (mg/l)	0.7	-	1.6
Total PO_4-P(mg/l)	0.11	0.08	0.10
NH_3-N (mg/l)	0.04	0.07	0.27
NO_3-N (Meters)	0.01	0.04	0.18

Phytoplankton	Cell Number	Percent of total	Cell Number	Percent of total	Cell Number	Percent of total
Total	5967	100	12030	100	1955	100
Bluegreen	3980	69.0	6926	57.6	931	44.8
Green	113	2.1	901	7.7	713	38.5
Yellowgreen	1824	34.6	4162	34.6	277	14.0
Euglenoid	0	0	21	0.1	17	0.9
Dinoflagellate	0	0	0	0	0	0
Cryptomonads	10	0.3	0	0	17	0.9

Sample Date Sample Depth	Temp (°C)	D.O. (mg/l)	pH (units)	Cond (umho/cm)	Temp. (°C)	D.O. (mg/l)	pH (units)	Cond. (umho/cm)	Temp. (°C)	D.O. (mg/l)	pH (units)	Cond (umho/cm)
S	14.0	10.3	8.3	425	12.0	12.2	8.1	435	16.2	9.2	8.0	460
1M	13.0	6.0	8.4	425	12.0	10.2	8.3	440	16.2	9.2	7.9	470
Bottom	13.8	6.2	8.2	440	12.0	9.0	8.3	435	16.2	9.7	8.1	480

Sampling Date Depth (Meters)	25 May	13 June	26 June	11 July
Air Temp. (°C)	27.0	23.0	27.0	24.0
Secchi Depth (Meters)	0.63	0.25	0.30	0.28
Bottom Depth (Meters)	2.65	2.65	2.65	2.72
BOD (mg/l)	3.0	6.6	4.6	27.0
Total PO_4-P(mg/l)	0.15	0.11	0.13	0.20
NH_3-N (mg/l)	0.11	0.04	0.10	0.01
NO_3-N (Meters)	0.34	0.10	0.01	0.00

Phytoplankton	Cell Number	Percent of total	Cell Number	Percent of total	Cell Number	Percent of total	Cell Number	Percent of total
Total	3815	100	234632	100	16807	100	3641	100
Bluegreen	2256	59.1	229153	97.7	13550	80.6	1426	39.2
Green	418	11.0	1223	0.5	785	4.3	364	10.0
Yellowgreen	1105	29.0	3424	1.5	2360	14.0	1841	50.5
Euglenoid	28	0.8	685	0.3	92	0.6	10	0.3
Dinoflagellate	0	0	137	0.1	0	0.1	0	0
Cryptomonads	0	0.1	0	0	83	0.5	0	0

Sample Date Sample Depth	Temp (°C)	D.O. (mg/l)	pH (units)	Cond (umho/cm)	Temp (°C)	D.O. (mg/l)	pH (units)	Cond (umho/cm)	Temp (°C)	D.O. (mg/l)	pH (units)	Cond (umho/cm)	Temp (°C)	D.O. (mg/l)	pH (units)	Cond (umho/cm)
S	26.2	8.5	8.0	450	23.0	8.8	8.4	460	27.5	13.0	8.6	390	24.1	9.4	9.3	485
1M	24.0	9.3	9.1	440	23.0	8.7	8.4	460	27.0	12.0	8.4	430	24.1	9.3	9.3	470
Bottom	23.0	7.3	8.3	460	23.0	7.7	8.4	450	25.5	5.5	9.2	420	24.0	7.7	9.5	475

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TABLE B-4
WATER QUALITY SAMPLING DATA AT LAKE MANAWA
(CORPS OF ENGINEERS) - SITE 2

Sampling Date Depth (Meters)	13 April	27 April	12 May
Air Temp(^{o}C)	13.5	17.0	15.0
Secchi Depth (Meters)	0.33	0.61	0.86
Bottom Depth (Meters)	2.35	2.29	2.31
BOD (mg/1)	9.0	2.9	3.9
Total PO_4-P (mg/1)	0.04	0.04	0.09
NH_3-N (mg/1)	0.06	0.05	0.25
NO_3-N (Meters)	0.0	0.04	0.16

Phytoplankton	Cell Number	Percent of total	Cell Number	Percent of total	Cell Number	Percent of total
Total	5197	100	6729	100	1340	100
Bluegreen	3327	64.0	2943	43.7	865	64.5
Green	455	8.8	629	9.4	171	12.8
Yellowgreen	1355	26.0	3094	46.0	304	22.7
Euglenoid	26	0.5	36	0.5	0	0
Dinoflagellate	9	0.2	9	0.1	0	0
Cryptomonoids	25	0.5	18	0.3	0	0

Sample Date Sample Depth	Temp (^{o}C)	D.O. (mg/1)	pH (units)	Cond (umho/cm)	Temp (^{o}C)	D.O. (mg/1)	pH (units)	Cond (umho/cm)	Temp (^{o}C)	D.O. (mg/1)	pH (units)	Cond (umho/cm)
S	14.2	11.3	8.5	400	12.0	12.4	8.4	440	16.0	9.2	8.2	460
1M	13.0	8.7	8.5	420	11.6	12.7	8.4	435	16.0	8.9	7.8	450
Bottom	12.2	7.5	8.4	430	11.8	11.7	8.4	440	16.0	8.9	8.1	460

Sampling Date Depth (Meters)	26 May	13 June	26 June	11 July
Air Temp(^{o}C)	27.0	25.0	27.0	24.0
Secchi Depth (Meters)	0.58	0.20	0.31	0.28
Bottom Depth (Meters)	2.0	1.68	2.29	2.04
BOD (mg/1)	3.0	3.8	3.1	2.7
Total PO_4-P (mg/1)	0.09	0.12	0.13	0.20
NH_3-N (mg/1)	0.06	0.01	0.03	0.01
NO_3-N (Meters)	0.24	0.07	0.0	0.0

Phytoplankton	Cell Number	Percent of total	Cell Number	Percent of total	Cell Number	Percent of total	Cell Number	Percent of total
Total	3295	100	74885	100	2821	100	3217	100
Bluegreen	1997	60.6	70409	94.0	2048	72.5	1623	50.5
Green	390	11.8	833	1.3	175	6.2	273	8.5
Yellowgreen	869	26.4	3357	4.4	566	20.1	1259	39.2
Euglenoid	40	1.2	187	0.3	24	0.9	15	0.5
Dinoflagellate	0	0	0	0	0	0	46	1.3
Cryptomonoids	0	0	0	0	8	0.3	0	0

Sample Date Sample Depth	Temp (^{o}C)	D.O. (mg/1)	pH (units)	Cond (umho/cm)	Temp (^{o}C)	D.O. (mg/1)	pH (units)	Cond (umho/cm)	Temp (^{o}C)	D.O. (mg/1)	pH (units)	Cond (umho/cm)	Temp (^{o}C)	D.O. (mg/1)	pH (units)	Cond (umho/cm)
S	24.2	8.4	8.1	460	23.5	10.2	8.4	410	28.0	13.5	8.4	440	24.1	7.8	8.5	470
1M	24.1	8.1	8.1	465	23.0	9.8	8.4	425	27.8	13.3	8.5	410	24.1	7.8	8.5	475
Bottom	24.1	7.8	8.3	460	23.0	9.6	8.5	420	26.8	10.6	8.3	410	24.1	7.7	8.5	470

TABLE B-4
WATER QUALITY SAMPLING DATA AT LAKE [illegible] - (CORPS OF ENGINEERS) - SITE 3

Sampling Date Depth (Meters)	13 April	27 April	12 May
Air Temp. (^oC)	13.5	16.5	15.0
Secchi Depth (Meters)	0.46	0.96	0.64
Bottom Depth (Meters)	1.13	1.10	1.21
BOD (mg/l)	10.8	3.1	1.3
Total PO_4-P (mg/l)	0.04	0.05	0.06
NH_3-N (mg/l)	0.03	0.03	0.22
NO_3-N (Meters)	0.07	0.02	0.16

Phytoplankton	Cell Number	Percent of total	Cell Number	Percent of total	Cell Number	Percent of total
Total	4078	100	4734	100	1282	100
Bluegreen	1950	47.8	2394	50.6	1085	84.6
Green	248	6.1	115	2.4	11	0.9
Yellowgreen	1844	45.2	2198	46.4	164	12.8
Euglenoid	8	0.2	18	0.4	11	0.9
Dinoflagellate	0	0	0	0	11	0.8
Cryptomonads	27	0.7	9	0.2	0	0

Sample Date Sample Depth	Temp. (^oC)	D.O. (mg/l)	pH (units)	Cond (umho/cm)	Temp (^oC)	D.O. (mg/l)	pH (units)	Cond (umho/cm)	Temp (^oC)	D.O. (mg/l)	pH (units)	Cond (umho/cm)
S	15	11.4	11.4	420	13.0	12.8	8.4	43[illegible]	16.0	9.8	8.2	470
Bottom	14	11.3	11.3	460	12.8	12.8	8.4	430	16.0	9.[illegible]	8.2	470

Sampling Date Depth (Meters)	26 May	13 June	26 June	11 July
Air Temp. (^oC)	24.0	25.0	26.0	26.0
Secchi Depth (Meters)	0.53	0.23	0.28	0.29
Bottom Depth (Meters)	1.13	1.31	1.28	1.19
BOD (mg/l)	3.0	4.2	2.8	3.9
Total PO_4-P (mg/l)	0.09	0.18	0.12	1.15
NH_3-N (mg/l)	0.08	0.01	0.09	0.01
NO_3-N (Meters)	0.27	0.01	0.0	0.0

Phytoplankton	Cell Number	Percent of total	Cell Number	Percent of total	Cell Number	Percent of total	Cell Number	Percent of total
Total	3542	100	41125	100	2703	100	2086	100
Bluegreen	1106	31.2	33470	81.4	1936	71.6	812	40.1
Green	1234	34.9	2331	5.7	227	8.4	61	3.0
Yellowgreen	1192	33.6	5316	12.9	469	17.4	1130	55.9
Euglenoid	0	0.3	0	0	41	1.5	9	0.4
Dinoflagellate	0	0	0	0	8	0.3	15	0.7
Cryptomonads	0	0	0	0	24	0.8	0	0

Sample Date Sample Depth	Temp (^oC)	D.O. (mg/l)	pH (units)	Cond (umho/cm)	Temp (^oC)	D.O. (mg/l)	pH (units)	Cond (umho/cm)	Temp (^oC)	D.O. (mg/l)	pH (units)	Cond (umho/cm)	Temp (^oC)	D.O. (mg/l)	pH (units)	Cond (umho/cm)
S	23.8	9.4	9.1	470	23.0	9.7	9.6	440	27.5	12.8	9.5	415	26.0	9.3	9.6	[illegible]
Bottom	23.8	8.9	9.3	460	23.0	10.0	9.6	430	26.3	11.6	9.5	410	26.0	9.2	9.6	[illegible]

TABLE B-4
WATER QUALITY SAMPLING DATA AT LAKE [illegible] -
(CORPS OF ENGINEERS) - SITE 4

Sample Date Depth (Meters)	27 April	12 May
Air Temp. (°C)	18.0	18.0
Secchi Depth (Meters)	0.56	0.58
Bottom Depth (Meters)	0.61	0.61
BOD (mg/1)	5.2	5.5
Total PO_4-P (mg/1)	0.05	0.10
NH_3-N (mg/1)	0.10	0.23
NO_3-N (Meters)	0.04	0.15

Phytoplankton	Cell Number	Percent of total	Cell Number	Percent of total
Total	19126	100	5694	100
Bluegreen	11617	60.6	2284	40.1
Green	1536	8.0	497	8.7
Yellowgreen	6354	33.1	2737	48.1
Euglenoid	21	0.1	99	1.7
Dinoflagellate	0	0	0	0
Cryptomonids	42	0.2	77	1.4

Sample Date Sample Depth	Temp (°C)	D.O. (mg/1)	pH (units)	Cond (umho/cm)	Temp (°C)	D.O. (mg/1)	pH (units)	Cond (umho/cm)
S	13.4	12.4	7.8	420	16.9	9.6	7.	360
Bottom	11.4	10.4	7.8	420	16.9	9.1	7.9	460

Sample Date Depth (Meters)	26 May	26 June	11 July
Air Temp. (°C)	31.0	29.0	24.0
Secchi Depth (Meters)	0.85	0.31	0.31
Bottom Depth (Meters)	0.85	0.98	0.91
BOD (mg/1)	9.0	5.6	4.8
Total PO_4-P (mg/1)	0.16	0.12	0.15
NH_3-N (mg/1)	0.22	0.04	0.02
NO_3-N (Meters)	0.25	0.01	0.00

Phytoplankton	Cell Number	Percent of total	Cell Number	Percent of total	Cell Number	Percent of total
Total	6422	100	11758	100	4019	100
Bluegreen	2869	44.7	10536	89.6	1981	49.3
Green	629	9.8	365	3.1	296	7.4
Yellowgreen	2880	44.9	797	6.8	1726	43.0
Euglenoid	0	0	17	0.1	16	0.3
Dinoflagellate	0	0	9	0.1	0	0
Cryptomonids	44	0.6	34	0.3	0	0

Sample Date Sample Depth	Temp (°C)	D.O. (mg/1)	pH (units)	Cond (umho/cm)	Temp (°C)	D.O. (mg/1)	pH (units)	Cond (umho/cm)	Temp. (°C)	D.O. (mg/1)	pH (units)	Cond (umho/cm)
S	25.8	7.2	7.7	450	29.0	12.7	8.7	380	24.3	9.3	500	8.4
Bottom	24.8	6.2	7.8	450	27.0	9.3	8.5	375	23.5	6.3	530	8.4

TABLE B-4
WATER QUALITY SAMPLING DATA AT LAKE MANAWA - (CORPS OF ENGINEERS) - SITE 4
*MOSQUITO CREEK INFLOW

Sample Date Depth (Meters)	13 April	13 June
Air Temp. (°C)	16.0	22.0
Secchi Depth (Meters)	0.41	0.25
Bottom Depth(Meters)	1.13	1.07
BOD (mg/1)	5.9	4.5
Total PO_4-P (mg/1)	0.04	0.20
NH_3-N (mg/1)	0.0	0.03
NO_3-N (Meters)	0.13	0.0

Phytoplankton	Cell Number	Percent of total	Cell Number	Percent of total
Total	3718	100	44544	100
Bluegreen	1801	48.5	37307	83.8
Green	430	11.6	4485	10.1
Yellowgreen	1462	39.3	2752	6.1
Euglenoid	25	0.6	0	0
Dinoflagellate	0	0	0	0
Cryptononids	0	0	0	0

Sample Date Sample Depth	Temp (°C)	D.O. (mg/1)	pH (units)	Cond. (umho/cm)	Temp. (°C)	D.O. (mg/1)	pH (units)	Cond. (umho/cm)
S	15.0	10.5	8.3	430	22.5	8.5	8.5	500
Bottom	14.1	9.6	8.2	440	22.5	8.5	8.4	500

* Mosquito Creek Inflow

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APPENDIX C

FORMULATION, ASSESSMENT AND EVALUATION OF DETAILED PLANS

Formulation of Alternatives

FORMULATION PROCESS

The formulation process in the study was continually reshaped by the introduction of new information and by the differing viewpoints of the various agencies involved. The initial formulation criteria provided by local interests were to develop alternatives that:

- would provide additional recreation and fish and wildlife opportunities; and
- would be compatible with the Lake Manawa State Park Master Plan.

Their specific concerns regarding recreation opportunities centered around increasing depths in the lake to improve boater safety and removing the American lotus from the three bays of the lake.

Primary concerns of the Corps of Engineers study team at the beginning of the formulation process were:

- water quality;
- impacts of dredging on benthic and aquatic species; and
- hydrologic interrelationships between the lake and the aquifer.

Formulation Criteria. Depths of water for different activities were developed from the preliminary report titled Methods of Assessing Instream Flows for Recreation authored by the Cooperative Instream Flow Service Group. The suggested depths for given recreation activities are shown in Table C-1.

Table C-1

SUGGESTED DEPTHS OF WATER FOR RECREATION ACTIVITIES

Activity	Physical Minimum Depth (feet)	Safety Minimum Depth (feet)	Optimum Depth (feet)
Fishing			
non-powered boat	0.5	1	3
motorized boat	2	3	4
Boating			
low powered	2	3	3 or more
high powered	2	4	4 or more
Canoeing	0.5	0.75	2.5 or more
Sailing	2	5	5
Waterskiing	5	8	8

The depth assumptions used as formulation criteria in the study were coordinated with the Heritage Conservation and Recreation Service.

Alternative Development. Alternative 1 was developed by Economic Research Associates (ERA) in its 1975 report. Alternative 1 failed to meet many of the criteria of both local interests and the study team. The alternative provided a sufficient safe boating depth for local interests; however, it did not provide very many additional acres for recreation and it did not reduce the area available for the growth of the American lotus. The alternative would have required an 18-acre diving area which would have been sufficient for 22,000 people at one time. It was felt that too much area had been designated for diving.

Alternative 1 also required removal of only about 2 feet of the 5-foot deep pool of fine, highly organic sediment present in the bottom of the lake. Because this sediment represented a ready source of nitrogen and phosphorous for growth of vegetation in the lake, it was deemed desirable to remove as much of this sediment as possible.

Alternative 2 was developed with the objectives of:

- removing the sediment pool in the center of the lake;
- causing a minimum amount of disturbance of benthic organisms;
- providing a diverse depth habitat for the fishery; and allocating a smaller area for diving.

Alternative 2 would also minimize the change in the hydrologic interrelationship between the lake and the aquifer. Further studies conducted during formulation of Alternative 2 indicated that potentially serious water quality problems could be incurred by dredging in the center of the lake. Elutriate tests revealed that high inorganic oxygen demand (IOD) and high concentrations of ammonia nitrogen could be generated during dredging in this area. Local interests were in favor of the deeper depths proposed in Alternative 2, as were the agencies with fish and wildlife concerns; the reduction in size of the diving area was also viewed positively. However, the alternative did not provide enough additional acres for recreation nor did it reduce the acres available for the growth of the American lotus. Alternative 2 did not interfere with any of the area inhabited by the American lotus because of concern over its status as a threatened species in Nebraska. Fish and wildlife agencies in Iowa do not attach great importance to the presence of the American lotus in Lake Manawa; therefore, it was indicated that reduction of the quantity of the species at the lake would be acceptable.

Alternative 3 required extensive dredging of the lake. Dredging would be required in all three bays of the lake to within 150 feet from shore. Alternative 3 would have removed most of the fine, highly organic sediments from the bottom of the lake and would have provided good depth diversity for the fishery. Local interests liked everything about Alternative 3 except the high cost. Alternative 3 would have been by far the most environmentally damaging alternative. Dredging in the southeast bay of the lake would have involved higher costs than anticipated because of the "tin can dike" across the mouth of the bay; this dike was constructed by locals. Dredging in this bay would not have been consistent with the Master Plan which has designated the area around the bay as a nature area.

Alternative 4 was developed to eliminate the problems associated with dredging in the southeast bay of the lake. Alternative 4 required dredging to about 150 feet from shore; this would leave a slightly larger area available for the growth of the American lotus.

After the four alternatives had been developed, the Iowa Conservation Commission requested that a fifth alternative be developed. The Commission wanted to provide dredging to the shoreline and to provide the most cost effective additional acres. In formulation of Alternatives 1 through 4, dredging was not extended closer than 150 feet from shore to minimize the need for shoreline protection. The Iowa Conservation Commission also felt that cost effective dredging should be interpreted as the dredging of as many acres as possible to the minimal depth necessary to provide safe boating during the life of the project. Alternative 5 would require dredging of about 344 acres to a depth of 6 feet and 1.2 acres to a depth of 12 feet. Dredging would be extended to the shoreline for a distance of 12,300 feet.

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Alternative 5 would substantially reduce the acres available for the growth of the American lotus but would leave the southeast bay of the lake untouched. Alternative 5 would not remove the highly nutritive sediments from the center of the lake, but the Iowa Conservation Commission indicated that water quality was not a concern at the lake. The problems of high IOD and ammonia nitrogen that would be released during dredging of the center of the lake would not occur with implementation of Alternative 5. Alternative 5 would also have the lowest cost per additional acre provided.

DREDGE SPOIL DISPOSAL AREA

Placement of the dredge spoil area was dictated by land ownership and the Master Plan. The State had already acquired 330 acres of land south of the lake with Land and Water Conservation Fund Act funds for use in expansion of the park. Placement of the dredge spoil disposal area was specified by the State to be in this area. Only 216 acres of the acquired land would be used as a dredge spoil site. Because the land purchased is presently in agricultural use, no significant adverse environmental impacts would result from disposal in this area. In approximately 10 years the dredge spoil area would include only hiking, biking, and natural camping. The dredge spoil area was positioned so that the existing Corps of Engineers levees could be used as two sides of the dredge spoil area. Consideration was given to constructing roads for park use on sufficient fill to allow them to function as dredge spoil disposal area levees; however, this would be very costly. Newly constructed levees would be designed to not interfere with the maintenance of sanitary sewers in the area. Spur levees would be provided to allow access for maintenance to the Iowa Power and Light Company lines which run through the designated dredge spoil disposal area.

The major objectives associated with dredge spoil disposal were:

- achieving adequate quality return flows from the dredge spoil area to the lake;
- preventing short-circuiting within the disposal area; and
- providing sufficient flexibility to allow dredging to progress at a steady rate.

The dredge spoil disposal area would be split into four compartments to achieve the objectives. This configuration would reduce short-circuiting of flows through the disposal area and would provide flexibility in the system. Because the type of material being dredged would vary from mostly sand to mostly fine silt, problems with accumulation of sand and gravel near the outlet of the discharge pipe could occur. Disposal into one primary detention area could be discontinued for a time and the sediments could be redistributed by earthmoving equipment.

The Iowa State Water Quality Standards specified requirements for turbidity in return flows to the lake. Results of testing indicated that material from some parts of the lake exhibited settling of only 20 percent of suspended solids after a period of 48 hours. Provision for chemical coagulation would, therefore, be provided in the secondary disposal area to insure that water quality standards are met.

Impact Assessment

All five alternatives share a common potential impact related to the fishery renovation program. The viability of the fishery and aquatic plant community in the lake is dependent on several water quality parameters. Aquatic plants require nitrogen, phosphorous, oxygen, carbon dioxide, and light to maintain life; the fish species require varying amounts of dissolved oxygen and many other elements to sustain life. The viability of the terrestrial animals is dependent on adequate habitat and sufficient food supply.

Lake Manawa, like other lakes in this geographic region has shallow, moderately hard, slightly alkaline water, thoroughly mixed by wind. Temperature profiles taken on this lake attest to the lack of thermal stratification which results in nutrient recycling within the water column. Under stratified conditions, particulate materials such as algae and soil particles, can settle out and become trapped in the lower more dense water layers. Under non-stratified conditions, this settling does not occur because of wind induced turbulence. Thus as dead cells break down and decay, the nutrients in the cells are released to the water column for reuse by other aquatic organisms such as bacteria and algae. Another evident feature of this lake is the simultaneity of parameter fluctuation at all sampling stations although some differences in magnitude are apparent. Thus it would appear that the lake is relatively similar in terms of water quality, both vertically and horizontally.

Lake Manawa is a turbid lake because wind and wave action and bottom feeding fish keep soil particles and algal populations suspended in the water column. Suspended soil particles appear to represent the largest proportion of this turbidity. The existing turbidity results in light limitation for algal populations. Any significant decrease in this parameter would likely result in algal population increases.

Increased algal population could take up substantial quantities of oxygen (by photosynthesis) during the night; this would reduce the DO content of the lake. Game fish such as bluegill, largemouth bass, crappie, and other species of sunfish would be most affected because their oxygen requirements are greater than those of bullheads, catfish, carp, and suckers. The amount of oxygen loss would dictate the affect on catfish and bullheads which are considered game species at the lake.

FUTURE HYDROLOGIC INTERRELATIONSHIP BETWEEN THE LAKE AND THE AQUIFER

Dredging may increase the rate of infiltration of water from the lake to the aquifer. The nature of the interrelationship between the lake and the aquifer has not been fully defined. Much more information would be needed, than is presently available, qualitatively to predict the impacts of dredging on the lake-aquifer interrelationship. The effects of dredging would be the removal of the fine material; an increase in bed sediment permeability and a consequent increase in bed sediment infiltration capacity.

It must be recognized that permeability is only one of several parameters which needs to be evaluated in assessing the possibility of increased lake infiltration losses under post-dredging conditions. The rate of infiltration, for example, is also directly proportional to the diffegence between the water level in the lake, and the surrounding water table. Minor differences between the two would mean that infiltration after dredging would not change even though the permeability of the bed sediments might have changed substantially. Much more information would be needed including data from the observation wells at the lake and core drill samples of the lake bed sediments and aquifer to determine the impacts of dredging on the lake-aquifer interrelationship.

PRIME AND UNIQUE FARMLAND

The potential project would have no direct effect on prime and/or unique farmland. The State of Iowa has already purchased the land on which the dredge spoil disposal area would be located. The land was purchased with Land and Water Conservation Fund Act funds for expansion of recreation areas at Lake Manawa State Park. Thus, the dredge spoil disposal area will be converted from agricultural to recreational land use. The current agricultural use of this land is the result of a temporary leasing arrangement.

Plan Evaluation

RELATIONSHIP TO FOUR ACCOUNTS

The beneficial and adverse impacts of each of the five alternatives as they relate to National Economic Development, Environmental Quality, Social Well Being, and Regional Development are discussed below. Impacts which could not be quantified and displayed in tabular form are discussed in the appropriate sections. There would be no impact on water conservation for any of the alternatives.

National Economic Development Account (NED). The NED account is a measure of change in the value of the output of goods and services and of the improvements in national economic efficiency. A discount rate of 6.875 percent and an economic life of 50 years was used to compute amortization costs.

Beneficial impacts in the NED account are basically social in nature. They may arise from an increase in the use of the lake or an increase in the value of that use. Because reliable data required to measure increases in benefits are lacking, and because these increases are likely to be quite small in comparison to the cost, NED benefits were not quantified. Adverse NED impacts include the first costs and the operation and maintenance costs of each alternative. Total costs and the cost of each additional acre made available for recreation are shown in table C-2.

Table C-2
National Economic Development Account (NED)

Adverse Impacts

	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
Project Costs	$4,910,000	$4,856,000	$6,672,000	$6,246,000	$4,566,000
Annual Operation and Maintenance	7,100[2]	7,100[2]	7,100[2]	7,100[2]	9,700
Annual Interest and Amortization Costs[1]	339,000	335,300	460,600	431,200	315,200
Total Annual Costs	346,100	342,400	467,700	438,300	324,900
Cost Per New Acre	37,000	97,000	32,000	51,000	17,000

[1] 6.875 percent interest rate, 50-year period.

[2] Operation and maintenance consists of the fishery renovation program.

Environmental Quality Account (EQ). The EQ account includes measures of EQ enhancement, EQ degradation and EQ destruction. The beneficial and adverse impacts of each alternative are shown in detail in table C-3.

EQ enhancement would include improvement of the fishery and fish habitat in the lake after the completion of dredging. The useful life of the lake would be increased by dredging. Turbidity would be reduced after the completion of dredging by implementation of a fishery renovation program.

EQ degradation would result from the reduction in the esthetic quality of the lake during the dredging period. Noise pollution would also degrade the environment during the dredging period. The esthetic quality of the dredge spoil area would also be reduced for a period of years after dredging. EQ degradation could also result from increased infiltration of lake water into the aquifer after dredging and increased growth of algae or macrophytes after dredging due to turbidity reduction.

EQ destruction would result from the removal of benthic organisms and aquatic vegetation from all dredged areas. The destruction of benthic organisms and aquatic vegetation would be temporary; most species would reestablish communities within 2 years following dredging.

EQ destruction would also result from the reduction in the number of water surface acres available for the growth of the American lotus.

Table C-3
Environmental Quality Account

	Alternatives				
Account	1	2	3	4	5
1. EQ enhancement					
Fishery improvement		1/			
Increased water volume for fishery support (cubic yards)	1,997,000	1,968,000	2,887,000	2,671,000	1,690,000
Improved fish habitat (linear feet of riprap)	0	0	0	0	12,300
Turbidity	reduced	reduced	reduced	reduced	reduced
2. EQ degradation					
Degraded esthetics and noise	dredge plant	dredge plant	dredge plant	dredge plant	dredge plant
Degraded esthetics in dredge spoil area		1/			
Increased infiltration to aquifer		1/			
Increased growth of algae by macrophytes		1/			
3. EQ destruction		1/			
Area of removal of benthic organisms and aquatic vegetation (acres)	400	275	475	435	345
Reduction of water surface acres available for American lotus	0	0	77	37	72

1/ See Environmental Quality Account discussion on page C-13.

__Social Well Being Account (SWB)__. The social well being account includes measurements of community disruption and changes in life and health. The account is divided into two categories of impacts, beneficial and adverse. These impacts are presented in detail in table C-4.

Beneficial impacts include an increase after dredging in the number of water surface acres available for recreation use, an increase in the shoreline fishing access, and a provision for a diving area. Boating and waterskiing safety would also be improved by dredging because sandbars and other obstacles would be removed from the lake bottom and the lake bed contours would be more predictable.

Adverse impacts would include the loss of recreation use, noise pollution, and degraded esthetics during dredging. The dredge plant is a noisy, esthetically unpleasing structure which would be positioned in various parts of the lake during the dredging process. Pipelines carrying dredge spoil to the detention basins would restrict access to various parts of the lake; this would severely inhibit recreation during ~~the~~ dredging operation. Unpleasant odors would be generated by anaerobic decomposition of the organic material in the sediment deposited in the dredge spoil areas during dredging and for a period of several years after dredging. Mosquito breeding areas would be created in standing water in the dredge spoil areas and in cracks formed as the dredge material dewaters.

Table C-4
Social Well Being Account

	Alternatives				
Account	1	2	3	4	5
Beneficial impact:					
Enhancement of safety		1/			
Acres available after dredging which are not presently available: with depth of 5' or greater	132	50	209	122	271
with weed free depth of 2' or greater	0	0	77	37	72
suitable for diving	18	1.2	1.2	1.2	1.2
Shoreline access provided for fishing (feet)	0	0	0	0	12,300
Adverse impact:					
Loss of recreation use of lake (months)	23	23	27	27	23
Creation of mosquito breeding area (acres)	216	216	216	216	216
Noise pollution		1/			
Loss of esthetic value		1/			
Creation of unpleasant odors		1/			

1/ See Social Well Being Account.

Existing recreation patterns would be disrupted during the dredging period when use of the lake is restricted. After dredging would be completed, increased visitation to the State Park could cause community disruption and disruption of existing recreation patterns.

Regional Development Account (RD). Implementation of any one of the alternatives would create changes in the condition of the land surrounding the lake; this could, in turn, alter the nature of the development. The only significant beneficial impact would be property enhancement. The only significant adverse impact would be the loss of productivity of the dredge disposal area. These impacts are presented in detail in table C-5.

Each of the dredging plans would improve the boating and fishing at the lake. As a result, both developed and undeveloped property surrounding the lake would be expected to increase in value. Approximately 84 percent of the surrounding property is publicly owned. The remaining 16 percent is privately owned. Most of the privately owned land is developed. There are, however, about 50 potential building sites remaining. All of these sites are owned by one individual.

The 216 acres required for disposal of dredged material would not be usable for other purposes for about 10 to 15 years after dredging. It would take this amount of time for fine sediment deposited in the dredge spoil area to dewater and consolidate.

Table C-5
Regional Development Account

	Alternatives				
Account	1	2	3	4	5
Property enhancement (lots)	50	50	50	50	50
Loss of use of dredge spoil site (acres)	216	216	216	216	216

SIGNIFICANT IMPACTS SPECIFIED IN SECTION 122 OF PL 91-611

ECONOMICS

Tax Revenues. None of the alternatives considered would affect the tax revenues.

Property Values. This impact is included in the Regional Development Account.

Public Services and Public Facilities. No alternative would result in an increase in the demand for public services or facilities.

(Desirable) Regional Growth. This impact is included in the discussion of the Regional Development Account.

Employment/Labor Force. None of the alternatives considered would affect the employment or labor growth.

Business and Industrial Activity. This impact is included in the discussion of the Regional Development Account.

Displacement of Farms. The dredge disposal site is presently being leased for agricultural production. It will be converted to recreation use when the master plan for Lake Manawa is completed.

SOCIAL

Noise. This impact is included in the discussion of the Environmental Quality Account.

Displacement of People. None of the alternatives considered would cause displacement of any people.

Aesthetic Values. This impact is included in the discussion of the Environmental Quality Account.

Community Cohesion. Since none of the alternatives would require relocation of any families or businesses, there would be no impact on community cohesion.

(Desirable) Community Growth. This impact is included in the discussion of the Regional Development Account.

ENVIRONMENTAL

Man-Made Resources. These impacts are included in the discussion of the Environmental Quality and Social Well-Being Accounts.

Natural Resources. These impacts are included in the discussion of the Environmental Quality Account.

Air. These impacts are included in the discussion of the Environmental Quality Account.

Water. These impacts are included in the discussion of the Environmental Quality Account.

COMPATIBILITY OF PLAN WITH ASSOCIATED CRITERIA

There are two associated criteria that are applicable for comparison of alternatives; these are compatibility of the alternative with the Lake Manawa State Park Master Plan and public acceptability.

Alternatives 1, 2, and 4 are equally compatible with the Master Plan. Alternative 3 would provide for dredging in the southeast bay of the lake; this area is adjacent to a proposed interpretive nature area and dredging of this bay would not be compatible with the Master Plan. Alternative 5 is more compatible with the Master Plan than Alternatives 1, 2, 3, and 4 in that it would provide 12,300 feet of shoreline access for fishing. None of the other alternatives would provide shoreline access.

Alternative 2 was not found to be publicly acceptable because of the small number of additional acres which would be provided for recreation and fish and wildlife opportunities. Alternative 5 was the most acceptable to local interests and to the ICC because of the relatively large gain in the number of acres for recreation and because the cost of Alternative 5 would be lower than for any of the other alternatives.

BENEFIT EVALUATION

Beneficial impacts arise from the increased use or value of use of the lake. NED benefits were not quantified for dredging because of data limitation. These data limitations are discussed below:

The determination of increased use or value of use would require knowledge of six parameters:

- present use of the lake;
- present rate of participation in specific recreation activities;
- future use of the lake;
- future rates of participation in specific reaction activities;
- present value of a recreation day at the lake; and
- future value of a recreation day at the lake.

The benefits attributable to dredging would be computed by subtracting the value of present water based recreation activities at the lake from the past dredging value of the future water based recreation activities.

The number of people using the lake is available from the daily count taken by the State Park Ranger. Present counts indicate that the lake and park experience use many times higher than the Iowa State Comprehensive Outdoor Recreation Plan standards. A 10-day survey conducted in 1975 attempted to determine the rate of participation in specific recreation activities; however, the validity of the survey could not be verified and it included only a small statistical sample. The data obtained from this survey was not used in benefit evaluation.

Table C-6 presents the historic annual visitation at Lake Manawa for the period from 1946 to 1977. Based on this data, it is not possible to discern a definite trend in visitation at the lake. Although substantial unsatisfied demand for recreation exists in the Lake Manawa area, it is not possible to substantiate estimates of the future use with the available data. The future rate of participation in specific recreation activities would be equally difficult to estimate with the available data.

The additional water surface acres at depths greater than 5 feet created by dredging would have recreation benefits in the form of increased boating and fishing opportunities. These benefits, however, have not been quantified because of the lack of reliable survey data. While it is safe to assume that some additional recreation would occur due to dredging, available data does not permit estimating the additional recreation days with any degree of confidence.

Establishing the present and future values of recreation presents some problems. The Principles and Standards for Water Resource Development stipulates that if simulated prices per recreation day are used to evaluate recreation benefits, the values used should fall within a range of $0.75 to $2.25 for general recreation days.

Table C-6
Historic Annual Visitation at Lake Manawa

Year	Visitation	Year	Visitation
1946	119,947	1962	432,750
1947	134,653	1963	710,755
1948	274,725	1964	363,595
1949	385,005	1965	601,205
1950	227,521	1966	437,910
1951	224,330	1967	617,180
1952	303,045	1968	450,263
1953	436,773	1969	853,359
1954	712,265	1970	623,843
1955	682,109	1971	705,248
1956	547,589	1972	315,600
1957	831,175	1973	594,580
1958	670,005	1974	570,877
1959	976,886	1975	457,870
1960	489,422	1976	685,593
1961	686,920	1977	690,406

Source: Iowa Conservation Commission

A general recreation day is one involving primarily those activities attractive to the majority of outdoor recreationists; these activities generally require the development and maintenance of convenient access and adequate facilities.

The Principles and Standards specifies a range of simulated values of $3.00 to $9.00 for specialized recreation days. A specialized recreation day is defined as one involving primarily those activities which often involve large personal expense by the user for which opportunities, in general, are limited, and intensity of use is low.

Recreation activities occurring at Lake Manawa are classified as general recreation days. The additional recreation activities attributable to dredging would also be classified as general recreation days.

It is conceivable that the recreation days at Lake Manawa are worth $2.25 per day--the upper range of the general recreation day values--but it is possible that they are worth less. The factor which indicates a higher value for at least the water oriented recreation days at Lake Manawa is the relative scarcity of water based recreation opportunities in the Omaha-Council Bluffs metropolitan area. Likewise, the additional recreation days created by dredging could be valued at $2.25 per day or less.

Because the number of recreation days that could be created have not been estimated, the value per recreation day is not an important consideration.

Another possible benefit component would be an increase in the value of the recreation experience for those persons presently using the lake and who would continue to use it after dredging. Again, problems are encountered with measuring these benefits because of the lack of reliable data concerning participation in specific recreation activities. However, it is doubtful that benefit component would be significant in any case. While it is conceivable that the value of a recreation day at Lake Manawa could be as high as $2.25 after dredging, it is also conceivable that the value of a recreation day under existing conditions approaches that amount. Project proponents insist that the present recreation at the lake is nearly worthless; however, recent visitation figures do not substantiate these views. The State of Iowa has not developed values for determining benefits at Iowa lakes.

Full evaluation of NED benefits was not included as part of the NED account due to lack of data. Based on criteria used for evaluation of recreation and fish and wildlife opportunities at Corps projects, it appears that the quantitative benefits would be considerably less than the project costs. The plan would, however, provide positive intangible and esthetic contributions to the consideration of environmental, regional, and social well being benefits.

ENVIRONMENTAL QUALITY

Impacts on environmental quality could be grouped into two primary categories:

impacts related to water quality; and
impacts related to fish and wildlife habitat.

WATER QUALITY IMPACTS

Water quality in Lake Manawa is typical of an overnitrified lake. High concentrations of nitrogen and phosphorus are common in Iowa lakes and, therefore, are not of great concern to agencies such as the ICC. The fine, highly organic sediments present in the center of the lake represent a pool of nutrients available for release into the lake water. Removal of this sediment, however, would not be considered to be an important beneficial impact of dredging.

The release of high concentrations of ammonia nitrogen would be considered to be an important adverse impact of dredging. Removal of ammonia nitrogen would be difficult and its impact on the fishery would be severe. The adverse impacts of ammonia nitrogen could be reduced significantly by avoiding dredging in those areas known to yield ammonia nitrogen, namely, the highly organic sediments in the center of the lake.

FISH AND WILDLIFE IMPACTS

Diversity of depth in the lake after dredging would have a beneficial impact on the fishery. Greater depths would also give additional protection against winter kill of the fishery. The placement of riprap along the shoreline of the lake would also provide additional fish habitat. Dabbling ducks and similar species would be benefited by the provision of shallow (18 to 24-inch depth), weed-free waters.

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APPENDIX D

PUBLIC VIEWS AND RESPONSES

Public Involvement Program

An active public involvement program has characterized the Lake Manawa study. Initial public involvement began with a Senate Public Works Committee Hearing held at Lake Manawa on 27 September 1975. Local interests, State agencies, and Federal agencies were active participants in the planning process of the Lake Manawa study.

Three primary public involvement techniques were used during the study: working committee meetings, informal meetings with local interests and agencies, and planning aid reports from State and Federal agencies. Working committee meetings occurred regularly and involved Lake Manawa Task Force members, Corps of Engineers representatives, and representatives of various State and Federal agencies. Two informal meetings were held in 1978 with groups of local interests at Lake Manawa and in Council Bluffs, Iowa.

Planning aid reports were prepared by the Iowa Conservation Commission, the Iowa Department of Environmental Quality, the Heritage Conservation and Recreation Service, and the U.S. Fish and Wildlife Service and furnished to the Corps of Engineers as part of the planning process. Copies of pertinent correspondence with State and Federal agencies are included in this appendix. On 10 August 1978 a final public meeting was held in Council Bluffs, Iowa to receive comments on the selected plan. Approximately 25 people were in attendance and no views were expressed for or against the plan.

LAKE MANAWA TASK FORCE

The primary local interest group associated with the Lake Manawa study is the Lake Manawa Task Force. The Task Force is composed of residents of the Lake Manawa/Council Bluffs area. The Task Force has been extremely visible throughout the study.

The task force and local interests strongly favor dredging, provided that Federal and State funds can be found for implementation. The city of Council Bluffs has indicated it has no capability to cost-share in dredging, and there does not appear to be any interest in forming a Lake Improvement District composed of landowners in the area to provide funding for dredging.

REVIEW OF THE DRAFT REPORT

The following comments on the Draft Report were received from Federal, State, and local agencies as well as the local public.

United States Department of the Interior
FISH AND WILDLIFE SERVICE
Rockcreek Office Building, Suite 106
2701 Rockcreek Parkway
North Kansas City, Missouri 64116

816-374-6166

June 20, 1978

Colonel James W. Ray
District Engineer
Omaha District, Corps of Engineers
6014 U.S. Post Office and Court House
Omaha, Nebraska 68102

Dear Colonel Ray:

This letter provides planning aid information to assist your agency in evaluating dredging alternatives for Lake Manawa, Council Bluffs, Iowa.

We understand that the following four alternatives are under consideration:

	Cubic Yds. Removed (mil)	Spoil Area (acres)
1.	2.0	155
2.	2.0	155
3.	2.9	155
4.	2.7	155

The 155 acre spoil area consists of agricultural land purchased by the State of Iowa. This is an excellent choice since no wetlands or other valuable habitat type is involved. We understand that the spoil area will eventually be turned into a park with bike trails, etc. Consideration should be given to planting the outside of the retaining dikes with native grasses. Also, wetland areas could be created outside the dike in conjunction with removing borrow material. These wetland areas, if constructed, should be located in areas which would blend with the Iowa Conservation Commission's plans for park development. Hopefully, they could become part of an "outdoor classroom."

From a fish and wildlife standpoint, we would place the four alternatives in the following priority:

Alternative 3 - This option would make a large percentage of the shoreline available to bank fishermen, since fishing is a popular activity on Lake Manawa. Also, alternative 3 would create more open water with suitable fishing depths.

Alternative 4 - The dredging associated with this alternative would provide less bank fishing opportunities and less fishable water (37 acres compared to 77 acres with alternative 3).

Alternative 1 - The dredging in the center of the lake would create a 10 foot depth as compared to 13 feet in the other alternatives. The greater depth (13 feet) would offer more "edge effect" and might decrease chances of a winter kill.

Alternative 2 - Little increase in bank fishing opportunity would be derived from alternative 2. The depths along the shoreline (8-10 feet) in the dredged sections would not offer as much diversity as the previous alternatives (5-10 feet). A variety of depths would increase fishing success, as well as providing greater diversity for fish spawning, feeding, and nursery areas.

A fifth alternative has been suggested by the Iowa Conservation Commission. This option would be similar to 3, however, the dredging would take place closer to the bankline along the main body of the lake, allowing better fishing access. If this alternative is considered, we would place it number one in priority.

If alternative 3 or 4 is selected, the quantity of fishing water would increase and the fishing experience would be enhanced. This is not to say, however, that the fish populations would be altered to any great degree. Any significant long-term change in the existing populations could only be accomplished through complete or selective kill, restocking and control of fish entering the lake through water diversions. It should also be noted that improved habitat diversity is equally important as an increase in more desirable fishing waters. Alternative 3, with depths ranging from five to 13 feet, would be the best alternative from this aspect. Along this line, consideration could be given to fish attractors such as anchored brush piles or other techniques as recommended by the Iowa Conservation Commission.

Lake Manawa is classed by the State of Iowa as a wildlife refuge and is located in the Central Flyway. Waterfowl hunting is allowed to within 50 yards of the bank or aquatic vegetation. The removal of the American Lotus or other aquatic vegetation might increase the area in which waterfowl hunting can take place, however, a certain amount of shallow water feeding areas for dabbling ducks might be degraded. Alternative 3, with the five foot depths at the upper ends of the lake arms would be the most desirable from this standpoint, however, ideal depths for dabbling ducks are 18-24 inches.

As noted in your impact comparison, adverse short-term impacts include loss of fishing opportunities, plant life and benthic organisms. These are largely unavoidable, however, other precautions can be taken to minimize adverse impacts. For example, pipelines transporting dredge spoil sometimes leak and spew material over valuable fish and/or wildlife habitat. To avoid this, the work should be closely monitored and pipeline crossings should be avoided over areas such as the public hunting lands on the south end of the lake.

We are aware of no Federally listed rare or endangered species, critical habitat or unique ecosystems that would be affected by the project.

It is encouraging to note that measures are being taken to control point and nonpoint sources of pollution. Septic tanks, a prime source of poor water quality, are being replaced by a central collection system. However, Mosquito Creek, a source of water for the lake, is nutrient rich and encourages excessive plant growth. Another less enriched water source would delay the eutrophication process.

We hope this input will assist the Corps in the planning process. Please contact us should you need further information.

Sincerely yours,

James M. Lutey

Tom A. Saunders
Area Manager

cc: RD, Denver, CO (ENV)
Iowa Conservation Commission
Des Moines, IA

March 3, 1849

United States Department of the Interior

~~BUREAU OF OUTDOOR RECREATION~~

MID-CONTINENT REGION

MAILING ADDRESS:
Post Office Box 25387
Denver Federal Center
Denver, Colorado 80225

STREET LOCATION:
663 Miller Court
Lakewood, Colorado
Telephone 234-2634

D6427

MAR 21 1978

Colonel James Ray, District Engineer
Omaha District, Corps of Engineers
6014 U.S. Post Office and Courthouse
Omaha, Nebraska 68102

Attention: Chief of Planning

Dear Colonel Ray:

Responding to your request of March 2, 1978, we have reviewed your analysis of recreation benefits associated with the Lake Manawa dredging project and offer the following comments.

Based on the materials provided for our review, your assumptions for benefit evaluation are reasonable. Unit-day values for boating are within the range of values provided in the *Principles and Standards for Water and Related Land Resource Planning*. It may be possible that a higher value for boating could be utilized if the survey conducted at Lake Manawa indicates a higher value to the recreationist using the area, or some other means of justifying a higher value can be shown.

If the dredging results in water quality improvement, some additional benefit may also be attributable to swimming primarily as a result of improving the quality of this activity.

You may wish to contact Fish and Wildlife Service for a determination of the accuracy of the fisherman-day value.

The acreage selected for dredge-spoil deposition was acquired with Land and Water Conservation Funds and should be so stated in your report. However, the approval of that project recognized that the site would be used for this purpose at some future date, therefore, a 6(f) conversion of use is not applicable.

We hope this information will assist you in completing your study of this project.

Sincerely,

Albert G. Baldwin
Assistant Regional Director
Resource Planning Services

COUNCIL BLUFFS
CHAMBER OF COMMERCE

August 11, 1978

Omaha District Engineer
U.S. Army Corps of Engineers
ATTN: Planning Division
6014 U.S. Post Office & Courthouse
Omaha, Ne. 68102

Dear Sir:

Over the past four years, the Council Bluffs Chamber of Commerce has actively sought the redevelopment of Lake Manawa State Park. The dredging, as designed by the US Army Corps of Engineers, is the single most important element of this redevelopment project.

Lake Manawa State Park,the most intensely used park of its size in the state, is an integral part of the recreation facilities in a metro area of over 500,000 population. Located within one mile of the Interstate 80/29 junction, it draws out-of-state travelers and serves as a major recreation area for southwest Iowa. Redevelopment of the park is the Chamber's first community development priority.

It is the opinion of the Chamber of Commerce that the Corps' proposed dredging Alternative 5 would provide maximum recreation use of the lake at the lowest possible cost to state and federal agencies. We, therefore, wholeheartedly support implementation of this dredging plan and thank the Corps for its execellent cooperation on the project.

Sincerely,

Ed Lynn

Ed Lynn
President

EL:cc

COMMISSIONERS
JOHN C. THOMPSON, Chairman—Forest City
THOMAS A. BATES—Bellevue
JOHN C. BROPHY—Lansing
JOHN G. LINK—Burlington
CAROLYN T. LUMBARD—Des Moines
MARIAN PIKE—Whiting
HERBERT T. REED—Winterset

IOWA

FRED A. PRIEWERT, Director
Wallace State Office Building, Des Moines, Iowa 50319
515/281-5145

An EQUAL OPPORTUNITY Agency

March 28, 1978

Ms. Carter Laing
Army Corps of Engineers
Omaha District
6014 U. S. Post Office
and Courthouse
Omaha, Nebraska 68102

Dear Ms. Laing:

As requested at the 3-16-78 meeting in your offices on the Lake Manawa dredging project, please find the following as my comments.

A comprehensive approach to developing a total lake restoration program is necessary. The approach of only looking at the aspect of dredging the lake as a solution to its problems is not valid. A comprehensive approach would evaluate the benefits to be obtained from restoration. Once the benefits have been defined, then a decision on proceeding with a specific restoration project will have some rational basis.

A comprehensive statewide approach for developing a restoration program, for example, would include an evaluation of the existing lakes, a classification of those lakes into different geomorphic categories, determination of benefits to be acheived, restoration program to be utilized, cost of the program, and establishment of statewide priorities.

To the general public, the term restoration appears to have become synonymous with the term dredging. To those who are knowledgeable, dredging may be only one of the tools utilized in a restoration program. Other tools include water management (including quantity and quality control), supplemental water supply, biological methods, mechanical methods, chemical controls, etc. Regardless of the tools utilized in developing a restoration program, the prime requisite prior to any action is the assessment of watershed conditions in terms of soil runoff and the control thereof; not only in terms of volume of sediment, but also in terms of the nutrient or chemical content therein.

In analyzing the cost of such a project assuming that the benefits derived merit proceeding with a project, it is necessary to assess those costs to the appropriate beneficiaries. In almost all situations in Iowa, a restoration project will provide a significant share of benefits to the private sector. In these situations, the private sector should share proportionately in those costs. Some states have initiated "lake improvement districts". A similar approach in Iowa may provide the mechanism for an equitable distribution of project costs.

In light of these comments, it may be desirable for you to develop a fifth alternative that would recognize and utilize the various tools in providing a total restoration program. If you feel that your authorization is not sufficiently broad to provide for that evaluation in your report, we would be willing to assist in obtaining a broader authorization so that an adequate job can be carried out by your agency. If you have any questions concerning these comments, please do not hesitate to contact me.

Sincerely,

G. F. SCHNEPF, ADMINISTRATOR
PLANNING AND COORDINATION

GFS/sc

cc: Ken Bedwell

FRED A. PRIEWERT, Director
Wallace State Office Building, Des Moines, Iowa 50319
515/281-5145

An EQUAL OPPORTUNITY Agency

May 9, 1978

Mr. John E. Velehradsky, P.E.
Chief, Planning Division
U.S. Army Corps of Engineers
6014 U.S. Post Office and Courthouse
Omaha, Nebraska 68102

Dear Mr. Velehradsky;

Personnel within our operating sections have reviewed Lake Manawa dredging Alternative 5 and expressed general agreement that this alternative is the most desirable of those considered to date. Contrary to the statement under "Fishery Renovation" on page 6, we feel that Alternative 5 could significantly improve opportunities for angler use of the fishery resource in Lake Manawa. Based on the 1976 creel survey, 93 percent of the angler hours recorded at Lake Manawa during the summer months were shore fishermen. Additionally, it is estimated that Lake Manawa is now supporting only about half the fishing pressure which a managed lake of its size could support.

Improvement of shoreline fishing as provided by Alternative 5, coupled with a fishery renovation program, would serve to meet expressed demands and to increase the realization of recreation potentials of Lake Manawa.

Thank you for the opportunity to comment. Please feel free to call if you have questions.

Sincereley,

G. F. SCHNEPF
PLANNING ADMINISTRATOR

GFS:dj

(4012)

deq iowa department of environmental quality
reply to: Dan R. Brindley
phone: 281-8949

February 9, 1978

John E. Velehradsky, P.E.
Chief, Planning Division
Omaha District Corps of Engineers
6014 U.S. Post Office & Courthouse
Omaha, NE 68102

Dear Mr. Velehradsky:

We have reviewed your letter of January 27, 1978, regarding proposed dredging of Lake Manawa.

Since the analyses of water quality impacts, as outlined in your letter is preliminary, we will not offer any particular comment at this time. We recognize that there will be some short term impacts, but our Water Quality Standards are designed to protect the various water uses by improving water quality. Since the project is intended to result in improved recreation quality of the lake, it will not be out of line with our water quality goals.

If the study indicates that long term improvement can be realized, we will not have serious objections to some short term degradation, so long as steps are taken to minimize the adverse impacts and it can be shown that there should be no permanent damage to the lake or to the dredge spoil area and groundwater.

We will, however, want to review the draft report when it is completed.

Sincerely,

CHEMICALS AND WATER QUALITY DIVISION

William Nicholas

William Nicholas, P.E., Chief
Planning Section

WN:DB:mla

DIVISION OF HISTORIC PRESERVATION
IOWA STATE HISTORICAL DEPARTMENT

ADRIAN D. ANDERSON. DIRECTOR
STATE HISTORIC PRESERVATION OFFICER

August 15, 1978

Mr. John Velehradsky
Chief, Planning Division
Corps of Engineers
6014 U.S. Post Office & Courthouse
Omaha, Nebraska 68102

RE: MROPD-P; OPP No. 790144; Draft review report, Lake Manawa, Iowa

Dear Mr. Velehradsky:

The opportunity to review and comment on the above referenced report is appreciated.

The study concludes that should the potential selected alternative be implemented an agency other than the Corps of Engineers would need to be authorized to provide the funding.

It is recommended that implementation of the potential alternative would not affect known cultural resources and the alternative could be implemented as planned without additional consideration for such resources.

These comments reflect the opinions of the State Historic Preservation Officer and the Office of State Archaeologist.

Sincerely,

Stan Riggle / for

Adrian D. Anderson, Director
State Historic Preservation Officer

ADA/eb

cc: Thomas Wallace, OPP
Boyd Claussen, COE

STATE OF IOWA

Office for Planning and Programming

523 East 12th Street, Des Moines, Iowa 50319 Telephone 515/281-3711

ROBERT D. RAY
Governor

ROBERT F. TYSON
Director

STATE CLEARINGHOUSE

PROJECT NOTIFICATION AND REVIEW SIGNOFF

Date Received: July 17, 1978 State Application Identifier: 790144

Review Completed: August 16, 1978

APPLICANT PROJECT TITLE:
Draft Review Report, Lake Manawa, Iowa Volumes 1 & II

APPLICANT AGENCY: Department of the Army
Address Omaha District, Corps of Engineers
6014 U.S. Post Office & Courthouse Omaha, Nebraska 68102

FEDERAL PROGRAM TITLE, AGENCY AND CATALOG NUMBER: Department of Defense
Department of the Army
Office of the Chief of Engineers

AMOUNT OF FUNDS REQUESTED:
NA

PROJECT DESCRIPTION:
Draft Review Report for Lake Manawa in Council Bluffs.

The State Clearinghouse makes the following disposition concerning this application:

☐ No Comment Necessary. The application must be submitted as received by the Clearinghouse with this form attached as evidence that the required review has been performed.

☒ Comments are Attached. The application must be submitted with this form plus the attached comments as evidence that the required review has been performed.

STATE CLEARINGHOUSE COMMENTS:

CH-14 Rev. 9-75

Federal Funds Coordinator

Natural Resources Council
Wallace State Office Building
Des Moines, Iowa 50319
(515) 281-5913

JAMES R. WEBB, Director
LOUIS F. GIESEKE, Water Commissioner

July 31, 1978

Mr. A. Thomas Wallace, Jr.
Federal Funds Coordinator
Office for Planning and Programming
State Capitol
LOCAL

Dear Mr. Wallace:

Re: Draft Review Report, Lake Manawa, Iowa, Volumes I and II

Receipt is acknowledged of letter of intent project number 790144.

Preliminary review indicates the project number 790144 appears to involve flood plain construction and, therefore, may require further consideration by the Iowa Natural Resources Council. When preparation of final project plan is initiated the applicant, his engineer, or agent should contact this office to determine the nature and extent of additional information which may have to be submitted for such Resources Council consideration.

If you have any questions, please do not hesitate to contact the Iowa Natural Resources Council.

Very truly yours,

Wayne Gieselman

Wayne Gieselman, P.E.
Chief Engineer

WG/da/pk

DEPARTMENT OF TRANSPORTATION IOWA

Department of Transportation
PLANNING AND RESEARCH DIVISION
800 LINCOLN WAY AMES, IOWA 50010 515-296-1661

REF. NO. 010.05

Mr. A. Thomas Wallace, Jr.
Federal Funds Coordinator
Office for Planning and Programming
523 East 12th Street
Des Moines, IA 50319

Dear Mr. Wallace:

Re: PNRS Letter of Intent, Project No. 790144, Lake Manawa report, Council Bluffs

We have received notice of letter of intent on this project. It is not in conflict with any programs in which the Iowa Department of Transportation is involved at this time.

We thank you for the opportunity of reviewing this submittal.

Very truly yours,

C. I. MacGillivray
Director
Division of Planning & Research

CIM:JFC:mkf

cc: James F. Cobb
Office of Program Mgt., Iowa DOT

212 Wildwood
Council Bluffs, Iowa
August 16, 1978

Dept of the Army
U.S. Army Engineer Dist, Omaha
Corps of Engineers
6014 U.S. Post Office & Courthouse
Omaha, Nebraska 68102

Re: Lake Manawa Improvements

Dear Sirs:

I am in favor of dredging Lake Manawa so it will improve recreation and fishing in this area.

Sincerely,

Mr. Jim Andersen

Jim Andersen

50   ckard Lane
Council Bluffs, Iowa
August 18, 1978

Re: Lake Manawa

Dear Sir:

We are very much in favor of dredging Lake Manawa so it can be more useful to mankind.

Sincerely,

John P. Andersen

John Andersen

August 1978

I am very glad to hear that the Corps Of Engineers has completed the feasibility study, showing the pros and cons of dredging Lake Manawa. I am extremely happy to find that the Corps and the Iowa Conservation Commission, have reached an understanding, that would give complete renovation of this high use area. I feel Alternative #5 in the feasibility study is the most all around best plan. I feel the Corps of Engineers have done a fine job in the study, I hope that with the results of the study, all of the public interest, Federal, State, and City, alike, that this cooperation can continue to see the complete renovation of Lake Manawa.

Kenneth C, Bedwell
14 Lakewood Villa
Council Bluffs, Iowa 51501

8223 Manderson
Omaha, Nebr.
August 18, 1978

Dear Sir:

I would like to see Lake Manawa dredged so it could be used for more recreation and fishing purpose. Thanks

Sincerely,

Richard S. Bischof

Omaha Nebraska
August 11, 1978

Dept of the Army -
Omaha Nebraska

We are in support of the redevelopment and dredging of Lake Manawa, Iowa. Boating waters are few near Omaha and Lake Manawa is a nice place to go.

Mr and Mrs Melvin Frame
2907 North 47th Street
Omaha Nebraska 68134

August 1978

Department of The Army
U.S. Army Engineer District, Omaha
Corps of Engineers
6014 U.S. Post Office and Courthouse
Omaha, NE 68102

The Omaha Area is drastically short of recreational facilities for water sport. We should take care and improve what facilities we now have.

I support the proposed development project now being considered for Lake Manawa.

D. William Giroux
#3 Lakewood
Council Bluffs, Iowa 51501

August 1978

Department of The Army
U.S. Army Engineer District, Omaha
Corps of Engineers
6014 U.S. Post Office and Courthouse
Omaha, NE 68102

I am in full support of the proposed development project now being considered for Lake Manawa.

As a resident of Omaha since 1959 I see that the project is long overdue. The people of our community have suffered a great loss by not having adequate facilities to enjoy water sports and other recreational activities.

Patricia M. Gonsior

Patricia M. Gonsior
12845 Drexel Street
Omaha, NE 68137

August 1978

Department of The Army
U.S. Army Engineer District, Omaha
Corps of Engineers
6014 U.S. Post Office and Courthouse
Omaha, NE 68102

As a resident of the Omaha Area, I support the proposed development project now being considered for Lake Manawa.

There is definitely a severe shortage of recreational facilities for the residents of Omaha and Council Bluffs.

Teresa Lavallee
7015 South 39th Ave.
Omaha, NE 68147

Neola, Iowa
August 17, 1978

Re: Improvements to Lake Manawa

Dear Sir-

I am in favor of the dredging Lake Manawa. This lake is a very popular place & would improve fishing and other water sports.

Please give it your up most consideration.

Sincerely,

Ms. Janice [illegible]
P.O. Box 576
Neola, Iowa
51559

12[illegible] 4th Street
Council Bluffs, Iowa
August 15, 1978

Re: Lake Manawa Dredging

Dear Sir:

We are concern about the dredging of Lake Manawa in order that this lake does not deteriobate any more. This could be a great recreation area.

Sincerely,

Mrs. Roberta Murphy

Roberta Murphy

August 1978

Department of The Army
U.S. Army Engineer District, Omaha
Corps of Engineers
6014 U.S. Post Office and Courthouse
Omaha, NE 68102

In regards to the proposed development project now being considered for Lake Manawa I am in full support.

The Omaha and Council Bluffs area is in drastic need of upgraded and additional recreational facilities.

Paul Peery

Paul Peery
821 So. 131st Ave.
Omaha, NE 68154

Department of The Army
U.S. Army Engineer District, Omaha
Corps of Engineers
6014 U.S. Post Office and Courthouse
Omaha, NE 68102

I have been following with interest the recent publicity concerning the development of Lake Manawa.

As an area resident for over 50 years with many fond memories of pleasant visits to Lake Manawa with family and friends, I sincerely endorse updating the facilities and improving the Lake area.

I recently reviewed the Lake Manawa, Iowa Study dated May 19, 1978. It is my personal opinion that Alternate #5, as described in the Study, would provide optimum development of Lake Manawa at reasonable cost.

R E Smathers

R. E. Smathers
1212 No. 145th Plaza
Omaha, NE 68154

We the undersigned have been following with interest the proposed dredging and improvement plan for Lake Manawa.

We are among the approximately 1/2 million people who can drive to Lake Manawa in 1/2 hour. Due to the shortage of water recreation sites in the area it is extremely important that we take care of and improve what sites we now have.

Lake Manawa has great potential that should be developed.

[illegible] Ackman
Karen Ackman
M. Brian Fennerty
Maureen A. Fennerty
Donna M. Wendt
Pat Gonsior
Becky Springer
Ann [illegible]
B. C. Gonsior
Lee Wendt
William B. [illegible]
Madelyn Naber
Richard Wymelenberg
Susan Wood

APPENDIX E

ENGINEERING INVESTIGATIONS DESIGN AND COST ESTIMATES

Testing Program

Three testing programs were initiated to provide the data necessary for sizing the dredge spoil disposal area, to determine the potential environmental impacts of dredging, and to obtain additional information on the water quality and biological community in the lake.

Sizing of a dredge spoil disposal area requires knowledge of the physical characteristics of the material being dredged. Sediment samples were classified and bulking factors for three samples were determined. The organic fractions of the samples were also determined. Testing was conducted in accordance with Department of Army Engineering Manual 1110-2-1906.

Sediment samples were collected at the sites shown on plate 1. Table E-1 presents the data collected during the testing. Table E-2 shows the sediment classification.

Table E-1
Sediment Data

Sampling Site	1	7	9
Jar Density, wet, grams/liter (g/l)	**1,803**	**1,331**	**1,806**
Mix, for 1100 g/l			
W_T, grams (g)	224.5	402.1	224.1
W_w, g	875.5	697.9	875.9
Theoretical, W_s, g	160.6	160.6	160.6
Oven dry, W_s, g	160.0	137.0	145.0
Actual initial slurry density, g/l	**1,100**	**1,085**	**1,090**
Graduate readings, V (settled vol)			
2 hr.	200	990	470
21 hr.	180	950	330
24 hr.	180	940	320
28 hr.	180	930	310
48 hr.	170	890	290
Slurry density at 48 hrs., g/l [1]	**1,590**	**1,096**	**1,311**
Bulking factor[2]	1.36	3.45	2.59

[1] Slurry density = $\dfrac{\left(V - \dfrac{W_s}{2.65}\right) + W_s}{V}$

Where $V - \dfrac{W_s}{2.65} = V_w$ in settled slurry at time T

[2] Bulking Factor = $\dfrac{D_{si} - 1000}{D_{ST} - 1000}$

NOTE: Density of the samples were obtained by first weighing the sample and jar, then placing a piece of polyethylene over the contents of the jar, filling the jar with water, and weighing the jar again. Densities determined for one jar only, and may not be exactly representative of composited sample used in test.

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Table E-2
Soil Classification Data

Sample	Plasticity (Atterburg limits)		Visual	Loss on	Plastic
No.	L.L.	P.I.	Description	Ignition*	Limit
Sampling Site 1 (composite)	26	0	Sandy silt	3.09%	26
Sampling Site 7 (composite)	155	123	Fat clay	8.90%	32
Sampling Site 9 (composite)	111	80	Fat clay	7.31%	31

*Specified in Department of Army Technical Memorandum 3-357, May 1967.

Elutriate tests were conducted on sediment samples to determine the potential environmental impacts of dredging. The elutriate tests were conducted in accordance with Appendix B of the Dredge Material Research Program Miscellaneous Paper D-76-17. The results of the elutriate test are presented in table E-3. Sampling sites are those shown on plate 1.

Sampling of the water quality and biological community in the lake was initiated in April 1978 by the Corps of Engineers and concluded in July 1978. The water quality sampling sites are shown on plate 2.

Table E-3
Elutriate Test Data

	Site 1 Water	Site 1 Elutriate	Site 7 Water	Site 7 Elutriate	Site 9 Water	Site 9 Elutriate
NH_3-N, ppm 1/	0.10	0.92	0.11	8.9	0.12	1.7
NO_3-N, ppm	0.00	0.02	0.00	0.00	0.00	0.01
IOD-O_2, ppm 2/			1940	1990	1690	1390
As, ppb 3/ 4/	L.T. 100	L.T. 100	L.T. 100	L.T. 100	L.T. 100	L.T. 100
Ba, ppb	110	301	118	265	118	176
Cd, ppb	0	0	0	0	0	0
Cr, ppb	0	0	0	0	0	0
Cu, ppb	4	4	4	8	4	4
Pb, ppb	0	0	0	13	0	0
Zm, ppb	5	5	6	30	9	15
Se, ppb	L.T. 100	L.T. 100	L.T. 100	L.T. 100	L.T. 100	L.T. 100
Phenol, ppb			0	0		
CN, ppb			0	0		
Hg, ppb	0.2	0.0	0.3	0.0	0.3	0.0

1/ ppm = part per million
2/ Immediate Oxygen Demand based on dry weight; values are replicates
3/ ppb = parts per billion
4/ L.T. = less than

Plan Description

ALTERNATIVE 1

Alternate 1 is shown on plate 3. Dredging would occur on 400 acres. Depths would vary from 6 to 12 feet depending on the use planned for different areas of the lake. The volume of spoil material created by dredging would be 1,997,000 cubic yards. A 16-inch hydraulic cutterhead dredge, operating for about 23 months, could accomplish the dredging at an estimated cost of $4,910,000. No dredging would be done within 150 feet from the shore; this would prevent shoreline sloughing and erosion and would eliminate the need for extensive riprapping of the shoreline. The annual cost of operation and maintenance would be $7,100. Table E-4 presents pertinent data on Alternative 1. The total area available for boating would be 472 acres and the total area available for fishing would be 550 acres.

ALTERNATIVE 2

Alternative 2 is shown on plate 4. This alternative would involve dredging 275 acres. Depths would vary from 8 to 13 feet. The volume of spoil material created would be 1,968,000 cubic yards. A 16-inch hydraulic cutterhead dredge, operating for about 23 months, could accomplish the dredging at an estimated cost of $4,856,000. No shoreline protection work would be required because dredging would not extend to within 150 feet of the shore. The annual operation and maintenance cost would be about $7,100. Table E-5 presents pertinent data on Alternative 2. The total area available for fishing would be 550 acres and the total area available for boating would be 390 acres.

Table E-4
Pertinent Data

Alternative 1

Volume of Excavation:	1,997,000 cubic yards
Area of Excavation:	400 acres (61 percent of lake area)
Dredging Plant:	16-inch cutterhead dredge and 16-inch pipeline with booster pumps at 1,600-foot intervals.
Dredge Spoil Disposal Area:	216 acres; a 10-foot high levee forms two primary detention basins with overflow weirs and two secondary detention basins. An earthen channel is provided to return flows from dredge spoil area to Lake Manawa. Average detention time in dredge spoil area is 7 days.
Construction Period:	23 months with levee construction to begin in fall.

Cost Estimate:

Items	Cost
Mobilization and Demobilization	$ 200,000
Dredging	2,996,000
Levees	157,000
Water Drainage (includes overflow weirs and drainage channels)	110,000
Chemical Coagulation	115,000
Seeding	8,000
Riprap	0
Fishery Renovation	126,000
Contingencies	557,000
Subtotal	$4,269,000
Engineering and Design	342,000
Supervision and Administration	299,000
Total Project Cost	$4,910,000
Annual Operation and Maintenance Cost	$ 7,100

Table B-5
Pertinent Data

Alternative 2

Volume of Excavation: 1,968,000 cubic yards

Area of Excavation: 275 acres (42 percent of lake area)

Dredging Plant: 16-inch cutterhead dredge and 16-inch pipeline with booster pumps at 1,600-foot intervals.

Dredge Spoil Disposal Area: 216 acres; a 10-foot high levee forms two primary detention basins with overflow weirs and two secondary detention basins. An earthen channel is provided to return flows from dredge spoil area to Lake Manawa. Average detention time in dredge spoil area is 7 days.

Construction Period: 23 months with levee construction to begin in fall.

Cost Estimate:

Items	Cost
Mobilization and Demobilization	$ 200,000
Dredging	2,955,000
Levees	157,000
Water Drainage (includes overflow weirs and drainage channels)	110,000
Chemical Coagulation	115,000
Seeding	8,000
Riprap	0
Fishery Renovation	126,000
Contingencies	551,000
Subtotal	$4,222,000
Engineering and Design	338,000
Supervision and Administration	296,000
Total Project Cost	$4,856,000
Annual Operation and Maintenance Cost	$ 7,100

ALTERNATIVE 3

Alternative 3 is shown in plate 5. This alternative would involve dredging 475 acres. Depths would vary from 5 to 13 feet. The volume of dredge spoil material would be 2,886,000 cubic yards. A 16-inch hydraulic cutterhead dredge, operating for about 27 months, could accomplish the work at an estimated cost of $6,672,000. No shoreline protection work would be anticipated because dredging would not extend closer than 150 feet from the shore. The annual operation and maintenance cost would be $7,100. Table E-6 presents pertinent data on Alternative 3. The total number of acres available for boating would be 549 and the total acres available for fishing would be 627.

ALTERNATIVE 4

Alternative 4 is shown on plate 6. Dredging would occur on 435 acres. Depths would vary from 6 to 13 feet. The volume of dredge spoil material generated by dredging would be 2,671,000 cubic yards. A 16-inch hydraulic cutterhead dredge, operating for 27 months, could accomplish the dredging at an estimated cost of $6,246,000. No shoreline protection would be anticipated because dredging would not extend closer than 150 feet from shoreline. The estimated annual operation and maintenance would be $7,100. The total acres available for boating would be 462 and the total number of acres available for fishing would be 587. Table E-7 presents pertinent data on Alternative 4.

Table E-6
Pertinent Data

Alternative 3

Volume of Excavation:	2,886,000 cubic yards
Area of Excavation:	475 acres (70 percent of lake area)
Dredging Plant:	16-inch cutterhead dredge and 16-inch pipeline with booster pumps at 1,600-foot intervals.
Dredge Spoil Disposal Area:	216 acres; a 10-foot high levee forms two primary detention basins with overflow weirs and two secondary detention basins. An earthen channel is provided to return flows from dredge spoil area to Lake Manawa. Average detention time in dredge spoil area is 7 days.
Construction Period:	27 months with levee construction to begin in fall.

Cost Estimate:

Items	Cost
Mobilization and Demobilization	$ 200,000
Dredging	4,329,000
Levees	157,000
Water Drainage (includes overflow weirs and drainage channels)	110,000
Chemical Coagulation	115,000
Seeding	8,000
Riprap	0
Fishery Renovation	126,000
Contingencies	757,000
Subtotal	$5,802,000
Engineering and Design	464,000
Supervision and Administration	406,000
Total Project Cost	$6,672,000
Annual Operation and Maintenance Cost	$ 7,100

Table E-7
Pertinent Data

Alternative 4

Volume of Excavation:	2,671,000 cubic yards
Area of Excavation:	435 acres (67 percent of lake area)
Dredging Plant:	16-inch cutterhead dredge and 16-inch pipeline with booster pumps at 1,600-foot intervals.
Dredge Spoil Disposal Area:	216 acres; a 10-foot high levee forms two primary detention basins with overflow weirs and two secondary detention basins. An earthen channel is provided to return flows from dredge spoil area to Lake Manawa. Average detention time in dredge spoil area is 7 days.
Construction Period:	27 months with levee construction to begin in fall.

Cost Estimate:

Items	Cost
Mobilization and Demobilization	$ 200,000
Dredging	4,007,000
Levees	157,000
Water Drainage (includes overflow weirs and drainage channels)	110,000
Chemical Coagulation	115,000
Seeding	8,000
Riprap	0
Fishery Renovation	126,000
Contingencies	708,000
Subtotal	$5,431,000
Engineering and Design	435,000
Supervision and Administration	380,000
Total Project Cost	$6,246,000
Annual Operation and Maintenance Cost	$ 7,100

ALTERNATIVE 5

Alternative 5 is shown on plate 7. Dredging would occur on 345 acres. The depth of about 344 acres would be 6 feet and the depth of 1.2 acres would be 12 feet. The volume of dredge spoil material created would be 1,690,000 cubic yards. A 16-inch hydraulic cutterhead dredge, operating for about 23 months, could accomplish the dredging at an estimated cost of $4,566,000. Dredging would extend to the shoreline for 12,300 feet and extensive shoreline protection would be necessary. Underwater slopes from the shore would be about 1 to 3 and other underwater slopes would be about 1 to 12. The total number of acres available for boating would be 611 and the total acres available for fishing would be 622. The annual operation and maintenance cost would be about $9,700. Table E-8 presents pertinent data on Alternative 5.

DREDGE SPOIL DISPOSAL AREA

The dredge spoil area is shown on plates 3 through 7. The dredge spoil material would be deposited in a 216-acre site south of the lake which is owned by the State. The site would be divided into four compartments by levees. A typical levee section would have a 10-foot top width and 1 to 3 slopes. The average levee height would be 10 feet. Two of the compartments would be primary disposal basins and two would be secondary disposal basins. Dredged material would be transported from the lake by pipeline and deposited in a primary settling basin where sand and heavier sediment would settle out of the water. Two primary detention areas would be provided to allow

Table E-8
Pertinent Data

Alternative 5

Volume of Excavation: 1,690,000 cubic yards

Area of Excavation: 345.0 acres

Dredging Plant: 16-inch cutterhead dredge and 16-inch pipeline with booster pumps at 1,600-foot intervals.

Dredge Spoil Disposal Area: 216 acres; a 10-foot high levee forms two primary detention basins with overflow weirs and two secondary detention basins. An earthen channel is provided to return flows from dredge spoil area to Lake Manawa. Average detention time in dredge spoil area is 7 days.

Construction Period: 23 months with levee construction to begin in fall.

Cost Estimate:

Items	Cost
Mobilization and Demobilization	$ 200,000
Dredging	2,535,000
Levees	157,000
Water Drainage (includes overflow weirs and drainage channels)	110,000
Chemical Coagulation	115,000
Seeding	8,000
Riprap	201,000
Fishery Renovation	126,000
Contingencies	518,000
Subtotal	$3,970,000
Engineering and Design	318,000
Supervision and Administration	278,000
Total Project Cost	$4,566,000
Annual Operation and Maintenance Cost	$ 9,700

flexibility in the disposal area. Because of the large quantities that would be deposited in the primary detention basins, it could become necessary to discontinue disposal into one basin and use earthmoving equipment to redistribute the sediment into another basin. Flow between the primary and secondary detention basins would be controlled by overflow weirs. The minimum detention time in the disposal area would be 7 days. Fine sediments suspended during dredging would not settle out by gravity in the dredge spoil area; therefore, chemical coagulants would be introduced into the flow between the primary and secondary detention basins. Laboratory tests conducted on these suspended sediments indicated that either alum or ferric sulfate in dosages of 50 milligrams per liter (mg/l) of dredge material would reduce turbidity to comply with the Iowa Water Quality Standards. Research conducted under the auspices of the Corps of Engineers Dredged Material Research Program has indicated that use of polyelectrolytes may be more cost effective than the use of conventional coagulants. A cost for chemical coagulation using conventional coagulants is included in the cost estimate for all five alternatives. The supernatant from the secondary disposal basin would be returned to the lake by means of an earthen channel. Under Public Law 92-500 a Section 404 permit would be required if dredging were implemented because the water would be returned to the lake. The elutriate tests conducted as part of this study would be applicable to the permit application.

FISHERY RENOVATION

Although dredging would have some beneficial impacts on fish and wildlife opportunities, none of the dredging alternatives would significantly improve the fish and wildlife opportunities at Lake Manawa. Wildlife opportunities are limited and will remain limited because of the urbanized character of the lake. **It was determined by the ICC that improvement of fishing opportunities could best be accomplished by implementation of a fishery renovation program. This program would involve selectively removing the rough fish species** present in Lake Manawa and replacing them with game fish species. Anamycin would be the preferred chemical for use in the removal program. Anamycin would eliminate rough fish but would not harm channel catfish or bullhead. Anamycin is also undetectable to carp, thereby, insuring a thorough removal of this species. Restocking species would consist of channel catfish, largemouth bass, crappie, bluegill, and tiger muskie. Table E-9 presents the restocking program suggested by ICC.

An impact of fishery renovation, however, would be a noticeable reduction in turbidity due to removal of carp and other bottom feeding species. This reduction in turbidity could have serious consequences. Aquatic plant growth in the lake is limited by both phosphorus and light availability. The decreased turbidity in the lake would allow much greater light penetration and would result in the rapid growth of either macrophytes or algae in the lake. Control of the growth of macrophytes in the lake could be accomplished by the release of white amur into the lake. This course of action

Table E-9
Fishery Restocking Program

Item	Cost
Selective removal with anamycin (kills all fish species in lake except channel catfish and bullhead)	$100,000

Restocking

Time	Species	Size	Number
Year of Renovation	Bluegill	1-2"	660,000
Year of Renovation	Channel catfish	2"	132,000
Renovation & 1 year	Largemouth bass	1-2"	46,200
Renovation & 1 year	Crappie	Adult	3,300
Renovation & 1 year	Tiger muskie	6"	3,300
Renovation & 1 year	Channel catfish	8"	6,600
Renovation & 2 years	Largemouth bass	1-2"	99,000
Renovation & 2 years	Channel catfish	8"	6,600
Renovation & 2 years	Tiger muskie	6"	3,300
Each year after 2 years	Channel catfish	8"	6,600
Each year after 2 years	Tiger muskie	6"	3,300

Renovation year cost:	$ 26,100
Year 1 cost:	16,500
Year 2 cost:	8,200
Annual cost after year 2:	7,100

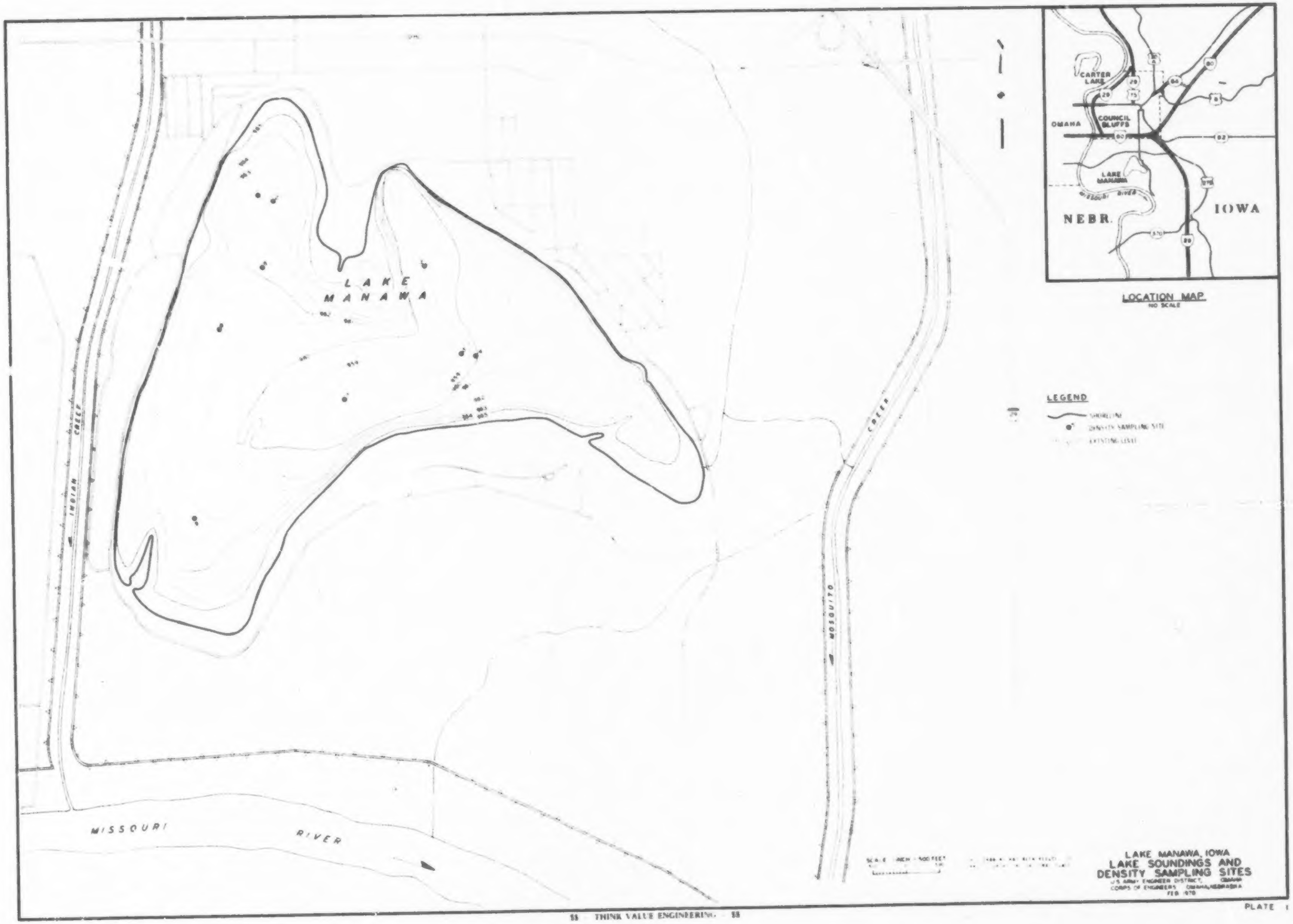
has been followed by the ICC in similar situations and the results have been acceptable. Control of a potential algal bloom would be very difficult. The fishery renovation program would be equally compatible with any of the alternatives. The cost of a fishery renovation program would be about $126,000 with an annual operation and maintenance cost of $7,100. The cost of fishery renovation is included in the cost of each alternative.

DIVING AREAS

Each alternative provides a diving area adjacent to the swimming beach proposed in the Lake Manawa State Park Master Plan. The diving area would be located 150 feet from shore and would have a depth of 12 feet. Underwater slopes in the diving area would be 1 to 12. Alternative 1 would have 18 acres of diving area and Alternatives 2 through 5 would provide 1.2 acres of diving area.

RIPRAP DESIGN

Riprap would be placed along the shoreline in areas where dredging would extend to the shoreline. Underwater slopes to the shoreline would be 1 on 3. A pool elevation of 967 feet m.s.l. was assumed for purposes of the design. Riprap protection would begin on the bank elevation 968 feet m.s.l. and extend underwater to elevation 961 feet m.s.l. A 12-inch layer of limestone underlain by filter cloth would be required. The maximum size of rock would be 120 pounds or 11.5 inches, the average size of rock would be 30 pounds or 7.5 inches, and the minimum size would be 4 inches. A total of 16,700 tons of riprap would be required to provide protection for 12,300 feet of shoreline.



LAKE MANAWA, IOWA
LAKE SOUNDINGS AND
DENSITY SAMPLING SITES
U.S. ARMY ENGINEER DISTRICT, OMAHA
CORPS OF ENGINEERS OMAHA, NEBRASKA
FEB 1970

PLATE 1

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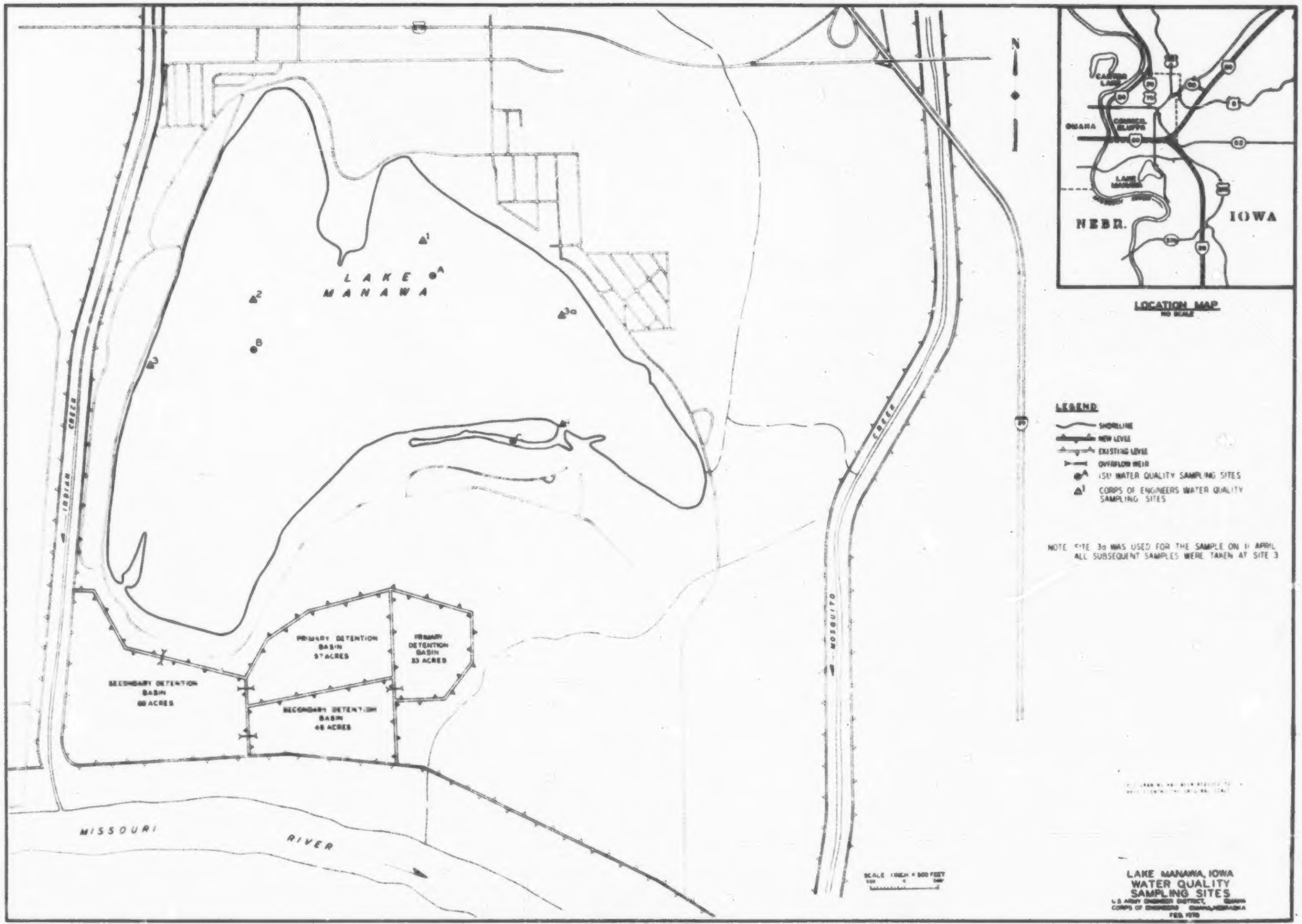
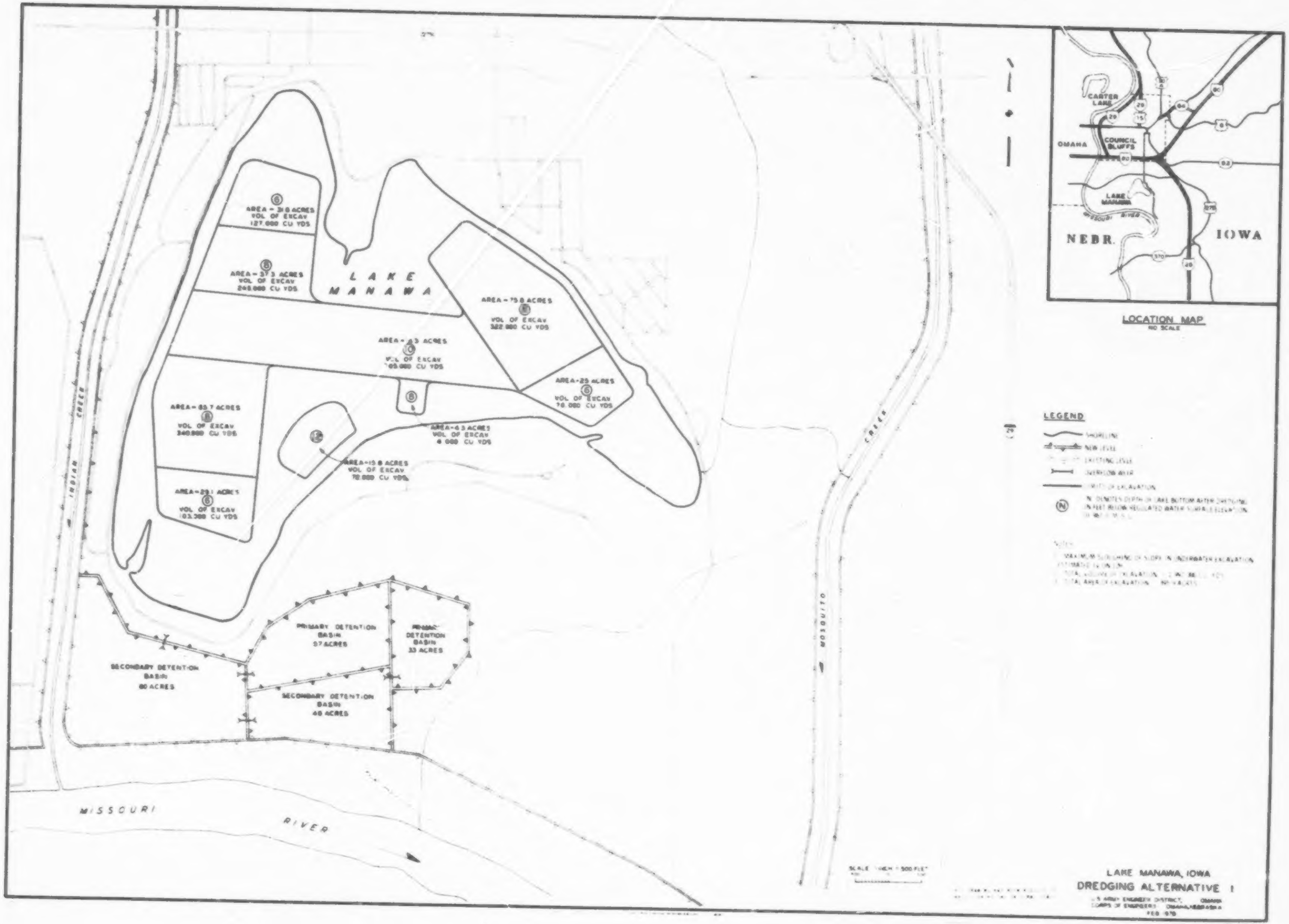

N
LAKE MANAWA
1
A
2
3a
B
3
4
INDIAN CREEK
MOSQUITO CREEK
MISSOURI RIVER
PRIMARY DETENTION BASIN 57 ACRES
PRIMARY DETENTION BASIN 33 ACRES
SECONDARY DETENTION BASIN 60 ACRES
SECONDARY DETENTION BASIN 46 ACRES
CARTER LAKE
OMAHA
COUNCIL BLUFFS
LAKE MANAWA
NEBR.
IOWA
LOCATION MAP
NO SCALE
LEGEND
SHORELINE
NEW LEVEE
EXISTING LEVEE
OVERFLOW WEIR
ISU WATER QUALITY SAMPLING SITES
CORPS OF ENGINEERS WATER QUALITY SAMPLING SITES
SCALE 1 INCH = 800 FEET

NOTE SITE 3a WAS USED FOR THE SAMPLE ON 11 APRIL
ALL SUBSEQUENT SAMPLES WERE TAKEN AT SITE 3

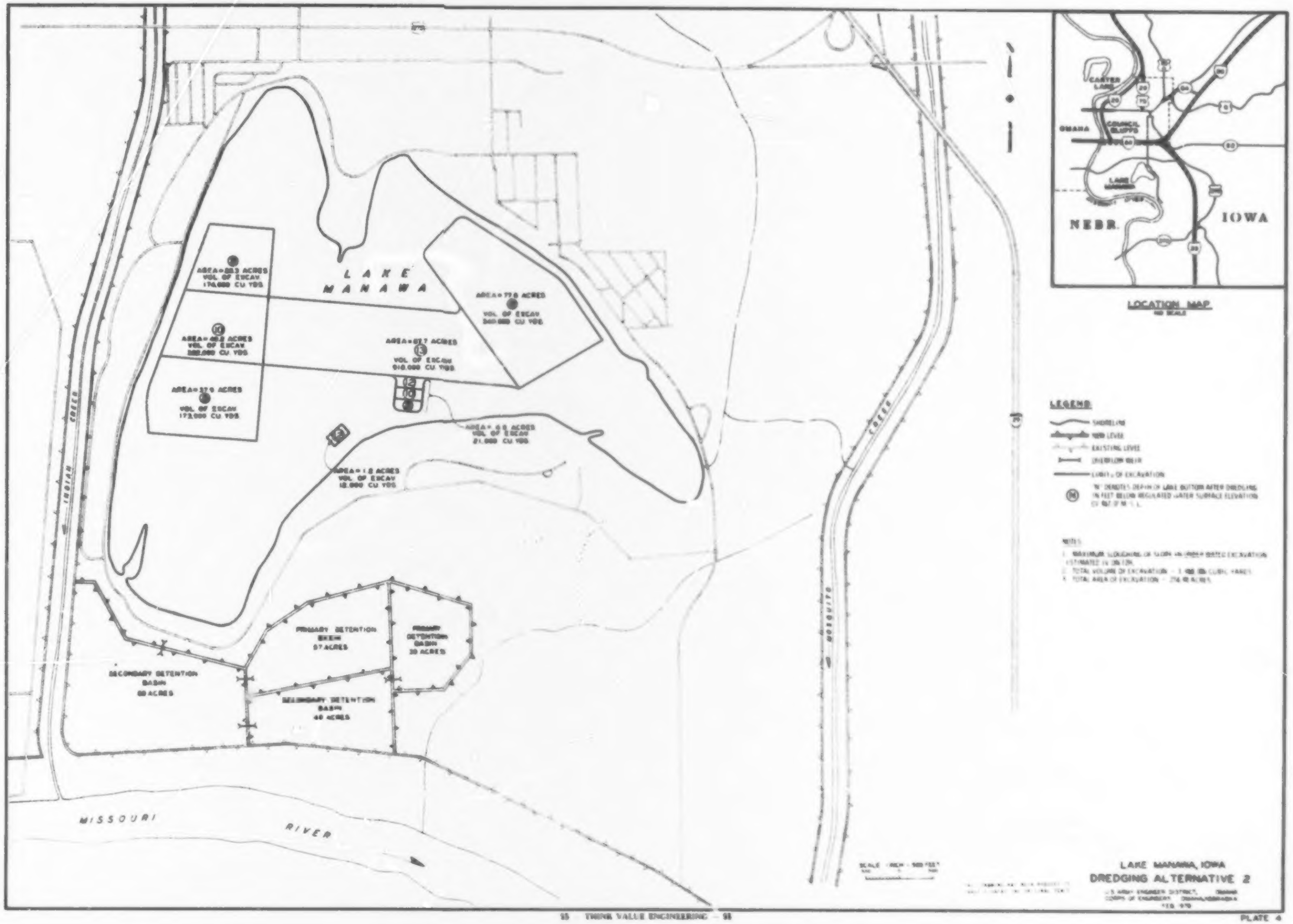
LAKE MANAWA, IOWA
WATER QUALITY
SAMPLING SITES
U.S. ARMY ENGINEER DISTRICT, OMAHA
CORPS OF ENGINEERS OMAHA, NEBRASKA
FEB. 1970

PLATE 2



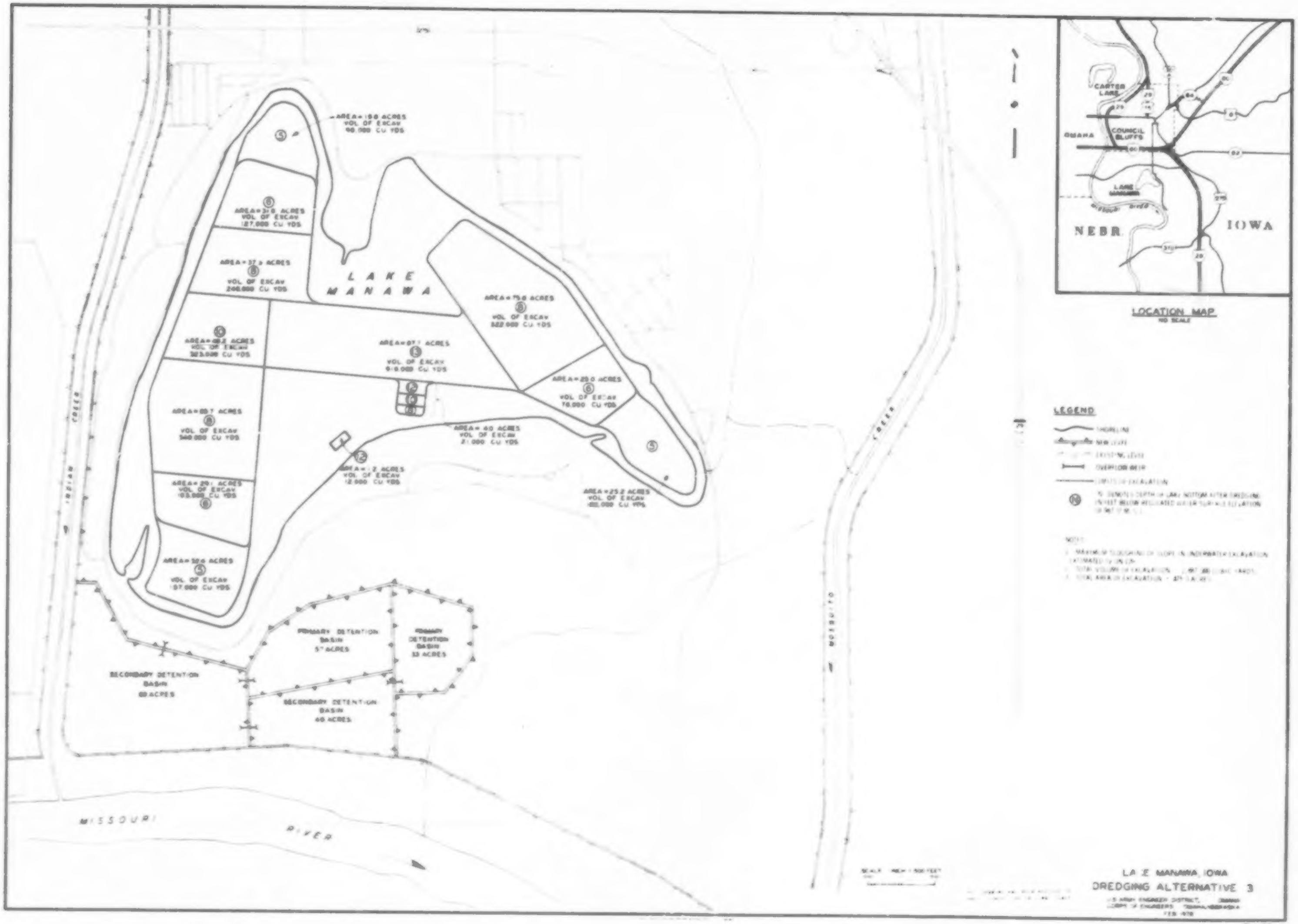
LAKE MANAWA, IOWA
DREDGING ALTERNATIVE 1
U.S. ARMY ENGINEER DISTRICT, OMAHA
CORPS OF ENGINEERS OMAHA, NEBRASKA
FEB 1978

PLATE 3


LAKE MANAWA
AREA=28.3 ACRES VOL OF EXCAV 174,000 CU YDS
AREA=40.2 ACRES VOL. OF EXCAV 282,000 CU. YDS
AREA=37.0 ACRES VOL OF EXCAV 172,000 CU YDS
AREA=87.7 ACRES VOL OF EXCAV 910,000 CU YDS
AREA=77.8 ACRES VOL OF EXCAV 340,000 CU YDS
AREA=6.0 ACRES VOL OF EXCAV 21,000 CU YDS
AREA=1.8 ACRES VOL OF EXCAV 12,000 CU YDS
12
10
PRIMARY DETENTION BASIN 57 ACRES
PRIMARY DETENTION BASIN 30 ACRES
SECONDARY DETENTION BASIN 60 ACRES
SECONDARY DETENTION BASIN 40 ACRES
INDIAN CREEK
MOSQUITO CREEK
MISSOURI RIVER
CARTER LAKE
COUNCIL BLUFFS
OMAHA
LAKE MANAWA
NEBR.
IOWA
LOCATION MAP
NO SCALE
LEGEND
SHORELINE
NEW LEVEE
EXISTING LEVEE
OVERFLOW WEIR
LIMITS OF EXCAVATION
"N" DENOTES DEPTH OF LAKE BOTTOM AFTER DREDGING IN FEET BELOW REGULATED WATER SURFACE ELEVATION
NOTES
2. TOTAL VOLUME OF EXCAVATION
3. TOTAL AREA OF EXCAVATION
SCALE 1 INCH = 900 FEET

LAKE MANAWA, IOWA
DREDGING ALTERNATIVE 2
U.S. ARMY ENGINEER DISTRICT, OMAHA
CORPS OF ENGINEERS OMAHA, NEBRASKA

PLATE 4



(N) DENOTES DEPTH OF LAKE BOTTOM AFTER DREDGING IN FEET BELOW REGULATED WATER SURFACE ELEVATION OF 967 FT M.S.L.

NOTES:

1. MAXIMUM SLOUGHING OF SLOPE IN UNDERWATER EXCAVATION ESTIMATED [illegible]
2. TOTAL VOLUME OF EXCAVATION = 3,487,000 CUBIC YARDS
3. TOTAL AREA OF EXCAVATION = 479.3 ACRES

LAKE MANAWA, IOWA
DREDGING ALTERNATIVE 3
U.S. ARMY ENGINEER DISTRICT, OMAHA
CORPS OF ENGINEERS OMAHA, NEBRASKA
FEB. 1978

PLATE 5

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REVIEW REPORT
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LAKE MANAWA, IOWA

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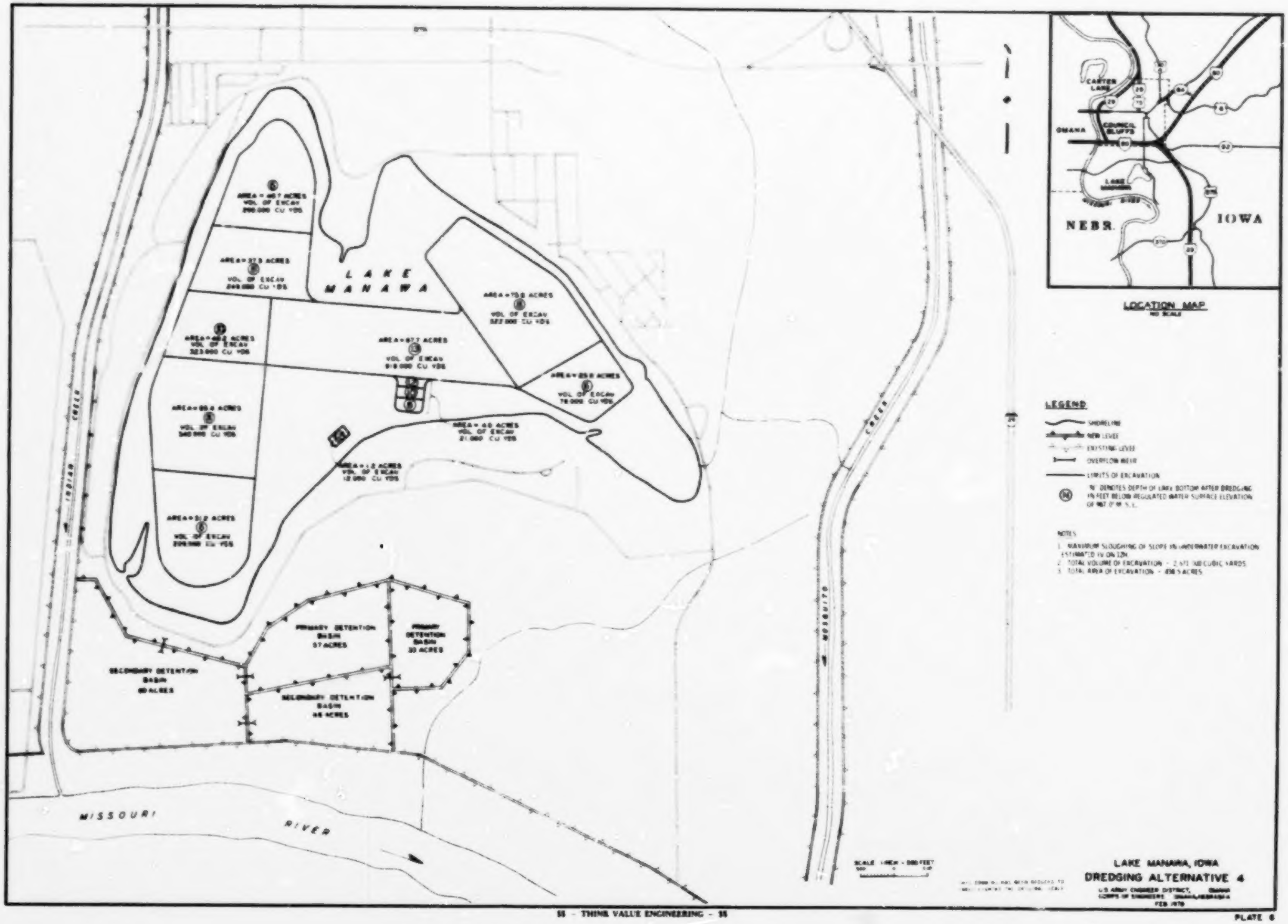

LEGEND

- SHORELINE
- NEW LEVEE
- EXISTING LEVEE
- OVERFLOW WEIR
- LIMITS OF EXCAVATION
- ⓝ "N" DENOTES DEPTH OF LAKE BOTTOM AFTER DREDGING IN FEET BELOW REGULATED WATER SURFACE ELEVATION OF 967.0 M.S.L.

NOTES

1. MAXIMUM SLOUGHING OF SLOPE IN UNDERWATER EXCAVATION ESTIMATED 1V ON 12H
2. TOTAL VOLUME OF EXCAVATION - 2,671,300 CUBIC YARDS
3. TOTAL AREA OF EXCAVATION - 436.5 ACRES

LAKE MANAWA, IOWA
DREDGING ALTERNATIVE 4
U.S. ARMY ENGINEER DISTRICT, OMAHA
CORPS OF ENGINEERS OMAHA, NEBRASKA
FEB 1979

PLATE 6

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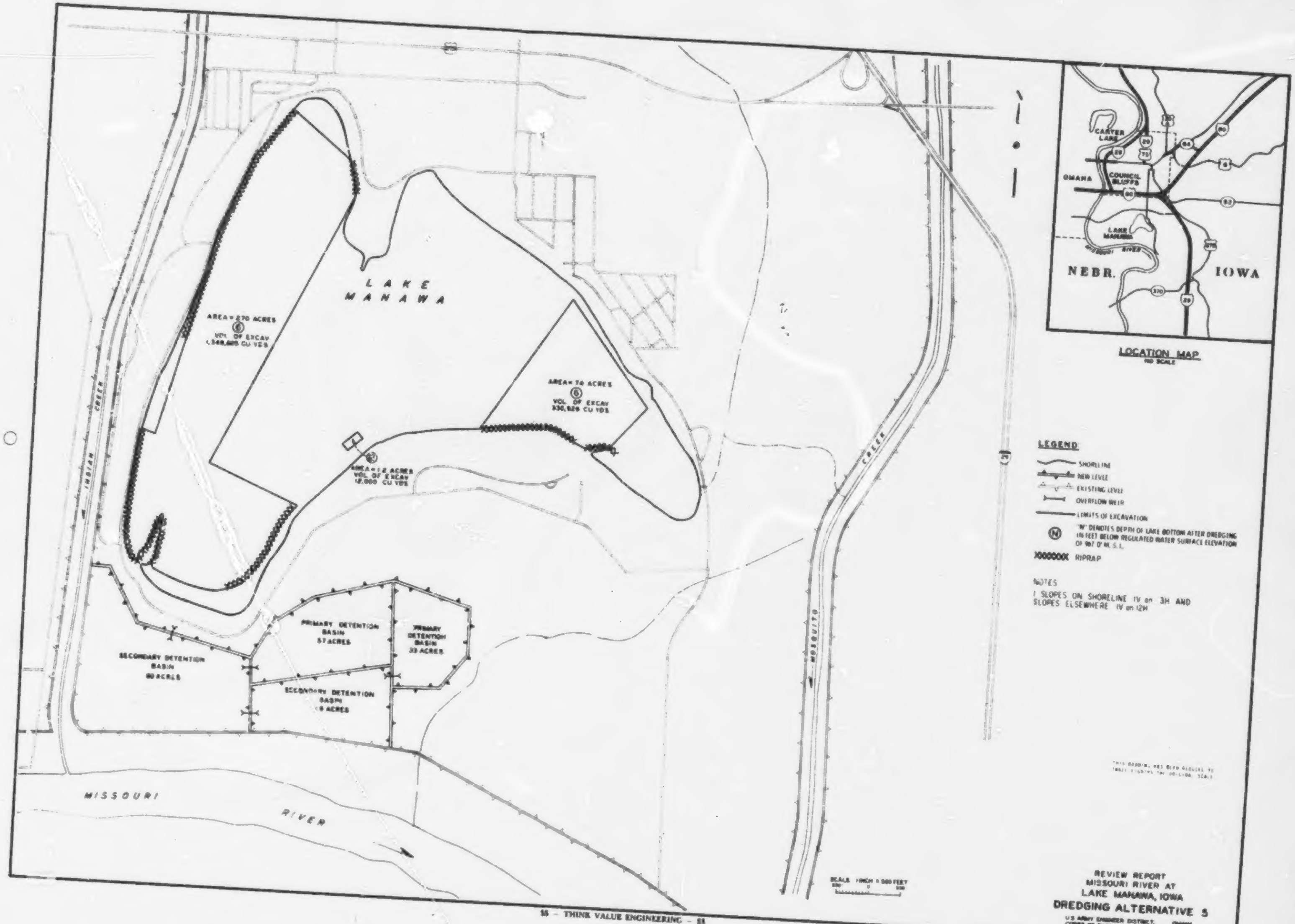

NOTES

1 SLOPES ON SHORELINE 1V on 3H AND SLOPES ELSEWHERE 1V on 12H

REVIEW REPORT
MISSOURI RIVER AT
LAKE MANAWA, IOWA
DREDGING ALTERNATIVE 5
U.S. ARMY ENGINEER DISTRICT, OMAHA
CORPS OF ENGINEERS OMAHA, NEBRASKA
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